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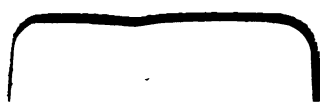
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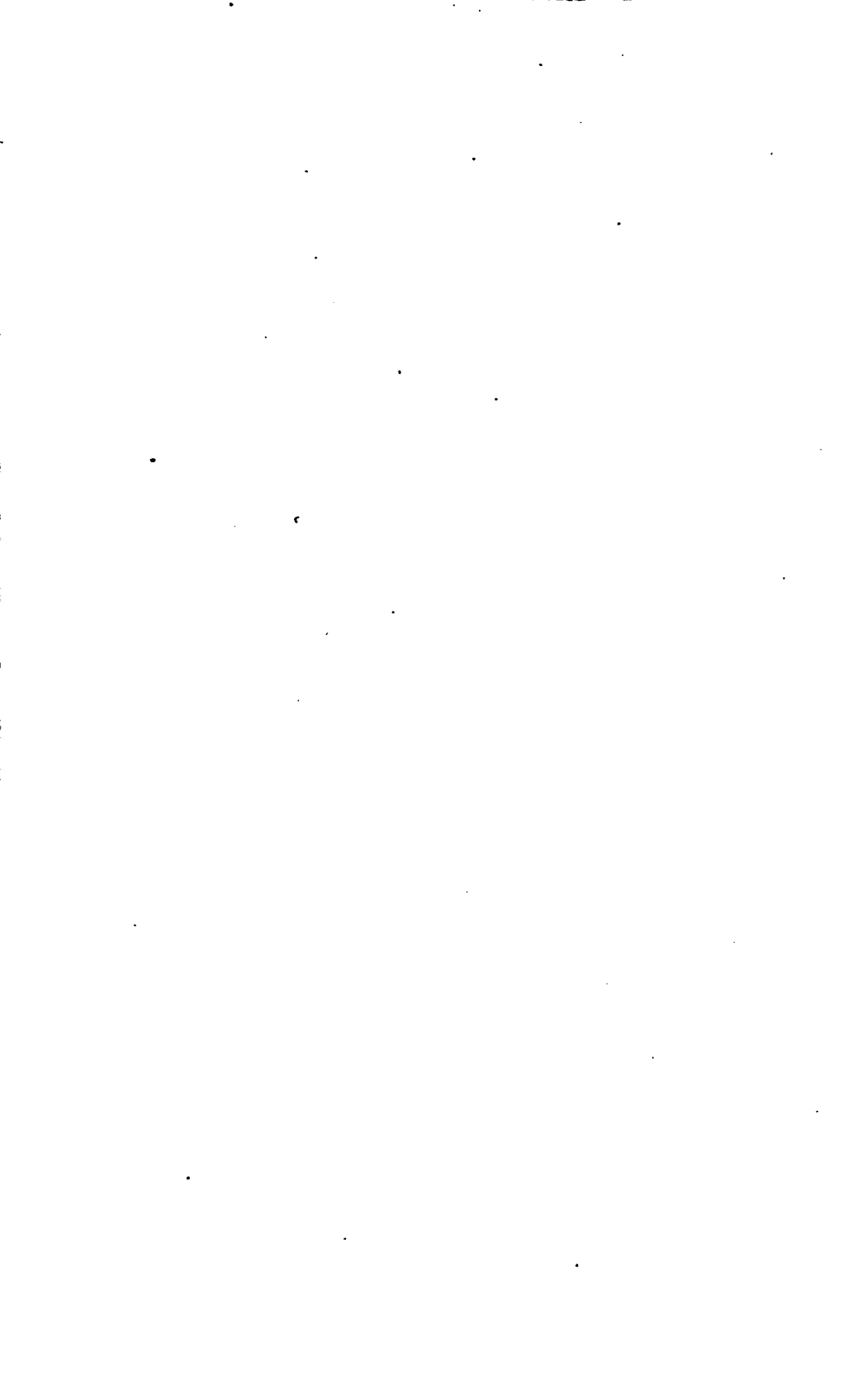
















# DISEASES

OF

# THE EYE

## A Handbook of Ophthalmic Practice

FOR

## STUDENTS AND PRACTITIONERS

BY

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Professor of Ophthalmology in the University of Pennsylvania; Consulting Ophthalmic Surgeon  
to the Philadelphia Polyclinic; Ophthalmic Surgeon to the Philadelphia Hospital;  
Ophthalmologist to the Orthopaedic Hospital and Infirmary  
for Nervous Diseases

With 280 Illustrations and Six Chromo-lithographic Plates

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**FOURTH EDITION, THOROUGHLY REVISED**

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## PREFACE.

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IN presenting the fourth edition of this text-book the author desires to express his high appreciation of the favorable reception which has thus far been accorded to it, and to say that it has been revised thoroughly and much new matter incorporated; indeed, many portions of it have been rewritten. Special paragraphs on the following subjects appear for the first time: Thomson's Lantern Test for Color-blindness; Hysterical Alopecia of the Eyelids; Metastatic Gonorrheal Conjunctivitis; Conjunctivitis Petrificans; Relapsing Traumatic Bullous Keratitis; Keratitis annularis et disciformis (Fuchs); Grill-like Keratitis (Haab); Atheromatous Ulcers of the Cornea, or Scar-keratitis; Ophthalmoscopic Signs of General Arteriosclerosis; Traumatic Perforations of the Macula Lutea, the so-called Holes in the Macula; Significance of Optic Neuritis; Retraction Movements of the Eyeball associated with Congenital Defects in the External Ocular Muscles; Divergence-paralysis; Recurring Oculomotor Paralysis; Educative Treatment of Strabismus; Ocular Signs of Diseases of the Sphenoid and Antrum; Acou; Dionin; Suprarenal Capsule and its preparations. Many therapeutic agents comparatively recently introduced, particularly the newer silver salts, are given in connection with the diseases in which they are indicated. The following chapters have been condensed materially, altered, or largely rewritten: Chapter I., General Optical Principles; the first portion of Chapter III.; Chapter IV., Normal and Abnormal Refraction; Chapter

XIX., the Movements of the Eyeballs and their Anomalies ; and a portion of Chapter XXII. on Operations. Separate paragraphs on the Pathology of the most important ocular diseases have been introduced, and for help in their preparation the author is indebted to Dr. EDWARD A. SHUMWAY. Dr. EDWARD JACKSON has again very kindly revised his chapter on Skiascopy. A number of new illustrations and six chromo-lithographic plates have been added.

## PREFACE TO THE FIRST EDITION.

---

THIS book has been written in the hope that it may prove of service to students and practitioners who desire to begin the study of ophthalmology.

The methods of examining eyes, and the symptoms, diagnosis, and treatment of ocular diseases have received the largest share of attention. The subject-matter has been given in greater detail than is customary in books written for students, because the author has been led to believe by those whom he has had the privilege of instructing in the Medical Department of the University of Pennsylvania, in the Philadelphia Polyclinic, and in the wards of the Philadelphia Hospital, that this presentation of the practice of ophthalmic science and the systematic examination of cases would be acceptable.

Certain illustrations, descriptions, and classifications taken from standard text-books and monographs, which have proved of special service in teaching students, have also been incorporated. These are properly acknowledged in the text, and a list of the books and brochures which have been constantly consulted during the preparation of these pages is also appended. Some previous writings of the author—*Affections of the Eyelids, Lacrimal Apparatus, Conjunctiva, and Cornea*, in Keating's *Cyclopædia of Diseases of Children*, Vol. IV.; *Congenital Anomalies of the Eye*, in Hirst's *System of Obstetrics*, Vol. II.; and *Diseases of the Eye* (Revision of the chapter) in Ashhurst's *Principles and Practice of Surgery* (Fifth Edition)—have also been utilized.



Dr. JAMES WALLACE, Chief of the Eye Dispensary of the University Hospital, has written Chapters I. and IV.; that portion of Chapter III. which relates to reflection, the ophthalmoscope and its theory, and the explanation of the direct and indirect method; and that part of Chapter XIX. which describes the mechanism of diplopia, the rotation of the eyeball around the visual line, and the causes of concomitant convergent and divergent squint. He has also given valuable advice and assistance in reading the sheets for the press. Dr. EDWARD JACKSON, Professor of Ophthalmology in the Philadelphia Polyclinic, has written the section on Retinoscopy. The author is indebted to these gentlemen for their aid, and for the presentation of the subjects entrusted to them in a manner which, he feels sure, will be satisfactory to students.

Messrs. J. H. GEMRIG and SON have very kindly furnished the cuts of the instruments which illustrate the chapter on Operations.

PHILADELPHIA : 1401 Locust St.,  
*March, 1892.*

# CONTENTS.

## CHAPTER I.

	PAGE
GENERAL OPTICAL PRINCIPLES . . . . .	17

Refraction, 17—Index of Refraction, 18—Prisms, 19—Refraction through a Prism, 19—Angle of Deviation, 19—Numbering Prisms, 20—Dennett's Method, 20—Prentice's Method, 20—Rays of Light, 22—Lenses, 24—Foci of Convex Lenses, 25—Foci of Concave Lenses, 27—Formation of Images by Lenses, 28—Focal Distance of a Lens, 31—Numeration of Lenses, 31—The Diopter, 32—Spheric Lenses, 34—Cylindric Lenses, 34—Combination of Lenses, 36—Visual Angle, 39—Visual Acuteness, 40—Limit of Perception, 40—Normal Acuteness of Vision, 40—Accommodation, 41—Angle Gamma, 47—Angle Alpha, 47—Convergence, 50—Meter Angle, 51.

## CHAPTER II.

EXAMINATION OF THE PATIENT AND EXTERNAL EXAMINATION OF THE EYE—FUNCTIONAL TESTING . . . . .	55
---	----

Direct Inspection of the Eye, 56—Blood-vessels of the Conjunctiva, 58—Temperature of Conjunctiva, 59—Inspection of the Cornea, 59—Diameter of Cornea, 60—Sensibility of Cornea, 60—Oblique Illumination, 60—The Corneal Loupe, 61—The Color of the Iris, 62—The Pupil, 62—Measurement of the Pupil, 63—Mobility of the Iris, 63—Pupil-reflexes, 63—Dilatation of the Pupil, 66—Contraction of the Pupil, 66—Unequal Pupils, 67—Special Pupil-phenomena, 67—Testing Acuteness of Vision, 68—Light-sense, 70—Color-sense, 71—Method of Holmgren, 71—Method of Thomson, 73—Lantern-test, 73—Pseudo-isochromatic Plates of Stilling, 75—Special Tests, 75—Accommodation, 75—Mobility of the Eyes, 76—Balance of the External Eye—Muscles, 76—Orthophoria, 77—Heterophoria, 77—Heterotropia, 77—Esophoria, 77—Exophoria, 77—Hyperphoria, 77—Cyclophoria, 78—The Screen (Cover) and Parallax Tests, 78—Prism Tests, 78—Equilibrium Test, 79—Obtuse-angled Prism Test, 82—Insufficiency of the Oblique Muscles (Cyclophoria), 83—Cobalt Test, 83—The Rod Test, 84—Power of Convergence, 87—Field of Vision, 88—Binocular Field of Vision, 92—Abnormalities of Visual Field and Scotomas, 96—Tension, 97—Proptosis, 98—Position of the Eyes, 98.

## CHAPTER III.

REFLECTION. THE OPHTHALMOSCOPE AND ITS THEORY. OPHTHALMOSCOPY AND SKIASCOPY . . . . .	PAGE 99
---	------------

Reflection, 99—The Ophthalmoscope, 102—Direct Method, 103—Size of the Image, 106—Indirect Method, 106—Size of the Image, 108—Ophthalmoscopy, 109—Direct Method of Ophthalmoscopy, 109—Examination of the Cornea and Lens by Transmitted Light, 111—Examination of the Vitreous, 112—Location of Opacities in the Transparent Media, 112—The Optic Nerve, 113—The Blood-vessels, 114—Physiologic Variations, 116—The Retina, 118—Macula Lutea, 118—The Choroid, 120—Determination of Refraction by the Ophthalmoscope, 121—Ophthalmoscopy by the Indirect Method, 127—Estimation of Refraction by the Indirect Method, 130—Ophthalmometry, 131—Optometry, 131—Skiascopy, 132—The Use of Mydriatics, 140.

## CHAPTER IV.

NORMAL AND ABNORMAL REFRACTION . . . . .	144
--	-----

Emmetropia, 144—Ametropia, 145—Hyperopia, 145—Determination and Correction of Hyperopia, 148—Ordering of Glasses, 152—Myopia, 154—Determination and Correction of Myopia, 160—Treatment of Myopia, 162—Ordering of Glasses, 164—Astigmatism, 166—Seat of Astigmatism, 167—Regular Astigmatism, 171—Recognition of Astigmatism, 172—Correction of Astigmatism, 173—Ordering of Glasses, 177—Irregular Astigmatism, 178—Surgical Treatment of Astigmatism, 179—Anisometropia, 179—Presbyopia, 180—Correction of Presbyopia, 180—Bifocal Lenses, 187—Spectacles and their Adjustment, 188.

## CHAPTER V.

DISEASES OF THE EYELIDS . . . . .	192
-----------------------------------	-----

Congenital Anomalies, 192—Erythema of Lids, 194—Erysipelas, 194—Abscess of the Lid, 194—Furuncle of the Lid, 195—Hordeolum, 195—Exanthematous Eruptions, 196—Eczema of the Lids, 196—Herpes Zoster Ophthalmicus, 197—Blepharitis, 198—Phthiriasis, 203—Syphilis of the Lids, 203—Tumors and Hypertrophies, 204—Xanthelasma, 205—Chalazion, 206—Sarcoma, 207—Carcinoma, 208—Lupus Vulgaris, 210—Lepra, 210—Elephantiasis Arabum, 210—Tarsitis, 210—Blepharospasm, 211—Ptosis, 213—Blepharochalasis, 213—Lagophthalmos, 213—Symblepharon, 214—Ankyloblepharon, 214—Blepharophthalmosis, 215—Trichiasis and Distichiasis, 215—Entropion and Ectropion, 216—Seborrhea, 218—Milium, 218—Molluscum Contagiosum, 219—Ephidrosis, 219—Chromidrosis, 219—Sebaceous Cysts, 220—Injuries, 220.

# Contents

II

## CHAPTER VI.

	PAGE
DISEASES OF THE CONJUNCTIVA . . . . .	223
Congenital Anomalies, 223—Hyperemia, 223—Conjunctivitis (Ophthalmia), 224—Simple or Catarrhal Conjunctivitis, 225—Acute Contagious Conjunctivitis, 226—Purulent Conjunctivitis, 229—Conjunctivitis Neonatorum, 229—Gonorrheal Conjunctivitis, 238—Metastatic Gonorrheal Conjunctivitis, 243—Croupous Conjunctivitis, 243—Diphtheritic Conjunctivitis, 245—Phlyctenular Conjunctivitis, 247—Spring Conjunctivitis, 249—Follicular Conjunctivitis, 250—Granular Conjunctivitis (Trachoma), 252—Sequels of Granular Lids, 258—Subacute Conjunctivitis, 263—Parinaud's Conjunctivitis, 264—Chronic Conjunctivitis, 264—Egyptian and Military Conjunctivitis, 265—Lacrimal Conjunctivitis, 265—Lithiasis Conjunctivæ, 265—Toxic Conjunctivitis, 266—Atropin Conjunctivitis, 266—Xerophthalmos, 266—Amyloid Disease of the Conjunctiva, 267—Conjunctivitis Petrificans, 268—Pterygium, 268—Pinguecula, 269—Abscess of the Conjunctiva, 269—Ecchymosis of the Conjunctiva, 269—Chemosis, 269—Emphysema, 270—Lymphangiectasis, 270—Syphilis, 270—Tumors and Cysts, 270—Lepra, 274—Lupus, 274—Tubercle, 274—Pemphigus, 276—Injuries, 277—Affections of the Caruncle, 277—Argyria Conjunctivæ, 278.	

## CHAPTER VII.

DISEASES OF THE CORNEA . . . . .	279
Keratitis, 279—Phlyctenular Keratitis, 279—Ulcers of the Cornea, 283—Results of Corneal Ulceration, 298—Staphyloma, 299—Xerotic Keratitis, 302—Neuroparalytic Keratitis, 303—Herpes Corneæ, 304—Keratitis Bullosa, 304—Relapsing Traumatic Keratitis Bullosa, 306—Vascular Keratitis, 307—Interstitial Keratitis, 308—Keratitis Punctata, 314—Keratitis Profunda, 315—Keratitis Superficialis Punctata, 315—Keratitis Marginalis, 316—Keratitis Annularis, 317—Grill-like Keratitis, 317—Filamentous Keratitis, 318—Riband-like Keratitis, 318—Blood-staining of the Cornea, 319—Arcus Senilis, 319—Conical Cornea, 319—Hydrophthalmos, 321—Injuries, 321—Foreign Bodies, 321—Tumors, 324—Congenital Anomalies, 325.	

## CHAPTER VIII.

DISEASES OF THE SCLERA . . . . .	327
Episcleritis, 327—Fugacious Periodic Episcleritis, 328—Scleritis, 329—Sclerokerato-iritis, 330—Staphyloma, 331—Abscess and Ulcers, 332—Tumors, 332—Injuries, 332—Foreign Bodies, 334—Congenital Pigmentation, 336.	

## CHAPTER IX.

DISEASES OF THE IRIS . . . . .	338
Congenital Anomalies, 338—Functional Motor Disorders, 340—Hyperemia, 341—Iritis, 341—Plastic Iritis, 347—Syphilitic Plastic Iritis, 347	

—Rheumatic Iritis, 350—Gouty Iritis, 351—Gonorrheal Iritis, 351—  
 Diabetic Iritis, 352—Parenchymatous Iritis, 352—Gummatous Iritis,  
 353—Gumma of Iris, 353—Scrofulous Iritis, 354—Infectious Disease  
 Iritis, 354—Idiopathic Iritis, 354—Traumatic Iritis, 355—Sympathetic  
 Iritis, 355—Secondary Iritis, 355—Serous Iritis, 355—Chronic Iritis,  
 356—Operations for Iritis, 357—Tumors, 358—Tubercle, 358—Sarcoma,  
 359—Injuries, 360—Foreign Bodies, 360—Iridodialysis, 360—Rupture  
 of the Sphincter, 361—Displacement of the Iris, 361—Anomalies of  
 the Anterior Chamber, 362.

## CHAPTER X.

DISEASES OF THE CILIARY BODY AND SYMPATHETIC IRRITATION AND  
INFLAMMATION . . . . . 363

Cyclitis, 363—Plastic Cyclitis, 363—Serous Cyclitis, 364—Purulent Cy-  
 clitis, 364—Injuries of the Ciliary Body, 365—Tumors of the Ciliary  
 Body, 366—Iridochoiritis, 367—Sympathetic Irritation, 369—Sym-  
 pathetic Inflammation (Ophthalmitis), 369.

## CHAPTER XI.

## DISEASES OF THE CHOROID . . . . . 377

Congenital Anomalies, 377—Hyperemia, 378—Choroiditis, 379—Super-  
 ficial, 382—Deep, 383—Diffuse Exudative Choroiditis, 383—Dissem-  
 inated, 384—Central, 386—Unclassified Forms of Choroiditis, 388—  
 Myopic, 389—Suppurative Choroiditis and Iridochoiritis, 391—Pan-  
 ophthalmitis, 392—Tumors (Sarcoma), 393—Carcinoma, 398—Tuber-  
 cle, 398—Injuries, 399—Foreign Bodies, 399—Rupture, 399—Hemor-  
 rhage, 400—Detachment, 400—Ossification, 401—Atrophy of the Eye-  
 ball, 401—Essential Phthisis Bulbi (Ophthalmomalacia), 401.

## CHAPTER XII.

## GLAUCOMA . . . . . 402

Varieties of Glaucoma, 402—Acute Glaucoma, 411—Subacute Glau-  
 coma, 413—Chronic Glaucoma, 414—Treatment, 421—Secondary  
 Glaucoma, 427—Hemorrhagic Glaucoma, 428—Complicated Glau-  
 coma, 428.

## CHAPTER XIII.

## DISEASES OF THE CRYSTALLINE LENS . . . . . 430

Congenital Anomalies, 430—Coloboma, 430—Lenticonus, 430—Cata-  
 ract, 430—Varieties of Cataract, 430—Senile Cataract, 438—Juvenile  
 or Congenital Cataract, 439—Complicated or Secondary Cataract, 442  
 —Traumatic Cataract, 442—After-cataract, 443—Capsular Cataract,  
 443—Capsulo-lenticular Cataract, 444—Artificial Ripening, 447—

# Contents

13

PAGE

Treatment of Immature Cataract, 447—Treatment of Mature and Complete Cataract, 448—Treatment of Partial Congenital Cataract, 448—Dislocation of the Crystalline Lens, 450—Foreign Bodies in the Lens, 452.

## CHAPTER XIV.

### DISEASES OF THE VITREOUS . . . . . 453

Hyalitis, 453—Purulent Inflammation, 453—Opacities, 455—Muscae Volitantes, 458—Hemorrhage, 459—Synchysis, 459—Synchysis Scintillans, 460—Blood-vessel Formation, 460—Foreign Bodies, 461—Entozoa, 461—Detachment, 461—Persistent Hyaloid Artery, 462.

## CHAPTER XV.

### DISEASES OF THE RETINA . . . . . 463

Hyperemia, 463—Anemia, 464—Hyperesthesia, 465—Anesthesia, 466—Retinitis, 468—Serous, 472—Parenchymatous, 472—Syphilitic, 473—Purulent, 475—Hemorrhagic, 476—Albuminuric, 477—Diabetic, 482—Leukocythemc, 482—Proliferating, 483—Circinate, 484—Central Punctate, 485—Striated Retinitis, 485—Pigmentary Degeneration, 486—Detachment, 490—Hemorrhages, 494—Changes in the Retinal Vessels, 496—Angioid Streaks in the Retina, 498—Aneurysms, 498—Embolism of the Central Artery, 498—Thrombosis of the Retinal Artery, 502—Thrombosis of the Central Vein, 502—Traumatisms, 503—Retinal Changes from the Effect of Sunlight and Electric Light, 505—Glioma, 506—Subretinal Cysticercus, 509—Symmetric Changes at the Macula Lutea in Infancy, 509.

## CHAPTER XVI.

### DISEASES OF THE OPTIC NERVE . . . . . 510

Congenital Anomalies, 510—Hyperemia, 511—Anemia, 512—Intra-ocular Optic Neuritis (Papillitis; Choked Disc), 513—Atrophy of the Optic Nerve, 523—Varieties of Optic-nerve Atrophy, 527—Primary Atrophy, 527—Secondary Atrophy, 527—Consecutive Atrophy, 527—Retinitic and Choroiditic Atrophy, 528—Hereditary Optic-nerve Atrophy, 529—Orbital Optic Neuritis (Retrobulbar Neuritis; Central Amblyopia), 531—Injury of the Optic Nerve, 536—Tumors, 536—Hyaline Bodies (Drusen) in the Papilla, 537.

## CHAPTER XVII.

### AMBYLOPIA, AMAUROSIS, AND DISTURBANCES OF VISION WITHOUT OPHTHALMOSCOPIC CHANGES . . . . . 539

Congenital Amblyopia, 539—Congenital Amblyopia for Colors (Color-blindness), 540—Reflex Amblyopia, 542—Traumatic Amblyopia, 542—Uremic Amblyopia, 543—Glycosuric Amblyopia, 543—Malarial

Amblyopia, 544—Amblyopia from Loss of Blood, 544—Amblyopia from the Abuse of Drugs, 545—Hysterical Amblyopia, 546—Pretended Amblyopia, 547—Night-blindness, 548—Day-blindness, 549—Snow-blindness, 549—Erythropsia, 550—Micropsia, 550—Megalopsia, 550.

## CHAPTER XVIII.

## AMBLYOPIA OF THE VISUAL FIELD, SCOTOMAS, AND HEMIANOPSIA . . 551

Partial Fugacious Amaurosis, 551—Amblyopia of the Visual Field, 551—Scotomas, 552—Hemianopsia, 554—Visual Tract, 554—Varieties of Hemianopsia, 556—Peculiarities of the Dividing Line, 559—Significance of Hemianopsia, 559—The Pupil in Hemianopsia, 561.

## CHAPTER XIX.

## MOVEMENTS OF THE EYEBALLS AND THEIR ANOMALIES . . . . . 562

Anatomy and Physiologic Action of the Ocular Muscles, 562—Rotation of the Eyeball around the Visual Line, 564—Associated Movements, 567—Binocular Vision, 567—Overcoming Prisms, 569—Field of Fixation, 569—Strabismus, Squint, or Heterotropia, 570—Paralysis of the External Ocular Muscles, 573—Varieties of Diplopia, 575—Paralysis of the External Rectus, 576—Paralysis of the Internal Rectus, 577—Paralysis of the Superior Rectus, 578—Paralysis of the Inferior Oblique, 579—Paralysis of the Inferior Rectus, 580—Paralysis of the Superior Oblique, 581—Oculomotor Paralysis, 582—Method of Examination and Diagnosis of the Affected Eye, 582—Recurrent Oculomotor Paralysis, 588—Retraction Movements of the Eyeball Associated with Congenital Defects in the External Ocular Muscles, 588—Divergence Paralysis, 589—Relative Frequency of Paralysis of the Orbital Muscles, 589—Ophthalmoplegia, 591—Associated Ocular Paralysis, 592—Paralysis of the Internal Ocular Muscles, 593—Concomitant Squint, 594—Varieties and Causes of Concomitant Squint, 594—Single Vision in Concomitant Squint, 598—Measurement of Squint, 599—Treatment of Concomitant Squint, 601—Results of Tenotomy in Convergent Squint, 606—Spastic Strabismus, 607—Abnormal Balance of the Ocular Muscles (Heterophoria), 607—Difference between Heterophoria and Heterotropia, 611—Nystagmus, 618—Monocular Diplopia, 619.

## CHAPTER XX.

## DISEASES OF THE LACRIMAL APPARATUS . . . . . 620

Dacryo-adenitis, 620—Hypertrophy of the Lacrimal Gland, 620—Atrophy of the Lacrimal Gland, 621—Spontaneous Prolapse of the Lacrimal Gland, 621—Fistula of the Lacrimal Gland, 621—Syphilis of the Lacrimal Gland, 621—Dacryops, 622—Tumors of the Lacrimal Gland, 622—Anomalies of the Puncta Lachrymalia and Canaliculi, 622—Anomalies of the Lacrimal Sac and Nasal Duct, 623—Dacryocystitis,

# Contents

15

PAGE

623—Prelacrimal Sac Abscess, 624—Fistula of the Lacrimal Sac, 625  
Obstruction of the Nasal Duct, 625—Cause of Disease of the Lacrimal  
Sac and Nasal Duct, 626—Character of the Lacrimal Secretion under  
Pathologic Conditions, 627.

## CHAPTER XXI.

DISEASES OF THE ORBIT . . . . . 632

Congenital Anomalies, 632—Periostitis, 633—Caries and Necrosis, 634  
—Cellulitis, 636—Inflammation of the Oculo-orbital Fascia, 638—  
Thrombosis of the Cavernous Sinus, 638—Tumors of the Orbit, 639—  
Pulsating Exophthalmos, 643—Exophthalmic Goiter, 644—Affections  
or Diseases of the Sinuses, 646—Diseases of the Frontal Sinus, 646—  
Diseases of the Ethmoid, 647—Diseases of the Sphenoid, 648—  
Diseases of the Antrum, 649—Injuries, 650—Dislocation of the Eye-  
ball, 650—Enophthalmos, 651.

## CHAPTER XXII.

OPERATIONS . . . . . 652

Preparation of the Hands of the Operator, 652—Preparation of the  
Skin of the Region of Operation, 652—Preparation of the Instruments,  
653—Dressings, 653—Sutures, 655—General and Local Anesthesia,  
655—Infiltration Anesthesia, 657—Local Hemostasis, 657—Operations  
upon the Eyelids, 658—Epilation of the Eyelashes, 658—Removal of a  
Meibomian Cyst, 659—Operations for Ptosis, 660—Tarsorrhaphy, 664—  
Canthoplasty, 664—Operations for Trichiasis, 665—Operation for Arti-  
ficial Lid-border, 666—Operations for Entropion, 667—Operations for  
Ectropion, 670—Blepharoplasty, 671—Transplantation without a Pedic-  
le, 674—Thiersch's Method of Skin-grafting, 674—Operations on the  
Conjunctiva, 675—Operations for Pterygium, 675—Operations for Sym-  
blepharon, 676—Transplantation of Rabbit's Conjunctiva, 677—Opera-  
tions for Trachoma, 678—Grattage, 679—Subconjunctival Injections,  
680—Operations on the Cornea, 680—Paracentesis Corneæ, 680—Appli-  
cation of the Actual Cautery, 681—Saemisch's Section, 681—Opera-  
tions for Staphyloma, 682—Tattooing the Cornea, 683—Operations  
upon the Iris, 683—Iridectomy, 683—Iridotomy, 687—Iridocystectomy,  
689—Operations upon the Sclera, 689—Sclerotomy, 689—Enucleation  
of the Eyeball, 690—Insertion of Artificial Eyes, 693—Evisceration of  
the Eyeball, 694—Mules's Operation, 695—Implantation of an Arti-  
ficial Globe in Tenon's Capsule after Removal of the Eyeball, 696—  
Extirpation of the Whole Contents of the Orbit, 697—Operations for  
Cataract, 699—Needle Operation (Discission), 699—Suction Method,  
701—Linear Extraction, 702—Extraction of Hard Cataract, 702—Ex-  
traction without Iridectomy, 703—Extraction with Iridectomy, 703—  
Extraction without Capsulotomy, 704—Preparation of the Patient and  
the Eye, 705—Position of the Patient, 706—Instruments, Solutions,



	PAGE
and Dressings, 707—After-treatment, 712—Accidents during Cataract Extraction, 713—Anomalies in the Healing Process, 715—Choice of an Operation, 721—Preliminary Iridectomy, 721—Operations for After-cataract (Secondary Cataract), 721—Operations upon the Eye Muscles, 723—Complete Tenotomy, 723—Partial or Graduated Tenotomy, 726—Advancement or Readjustment, 728—Operation for Shortening the Tendon, 731—Operations upon the Lacrimal Apparatus, 732—Slitting the Canaliculus, 732—Introduction of the Lacrimal Probe, 732—Incision of a Stricture, 733—Introduction of the Lacrimal Syringe, 733—Excision of the Lacrimal Sac, 734—Extirpation of the Lacrimal Gland, 735—Extirpation of the Palpebral Portion of the Lacrimal Gland, 735.	

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## APPENDIX.

The Use of the Ophthalmometer, 736—The Use of the Tropometer, 740.
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# DISEASES OF THE EYE

## CHAPTER I

### GENERAL OPTICAL PRINCIPLES

**Refraction.**—By refraction of light is meant the alteration which takes place in the direction of luminous rays, which pass obliquely from one medium into another of different density.

A ray of light passing through air keeps the same direction

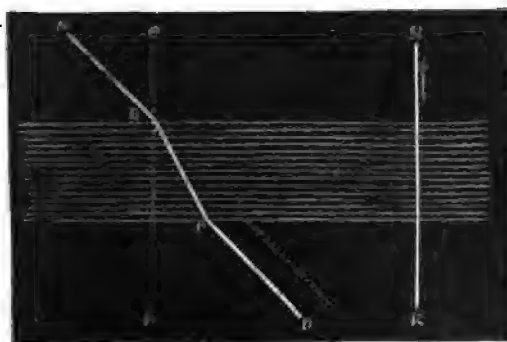


FIG. 1.—Refraction of light through a plate of glass bounded by plane surfaces which are parallel. *AB* is the incident ray; *BC*, the same ray, refracted by the first surface, nearer to the perpendicular, *PP*. *CD*, the same ray, refracted by the second surface, becomes parallel to *AB*, its original direction. The ray *HK*, perpendicular to the surfaces *B* and *C*, undergoes no refraction.

until it strikes obliquely the surface of a denser medium, when its course is changed toward the perpendicular to that surface. If this denser medium is a piece of glass bounded by parallel sides, the ray, as it passes through the second surface, is bent back again into the rarer medium.

Rays passing from a denser into a rarer medium are deviated from the perpendicular. The ray now has a direction parallel to its original course; the sides being parallel, the deviation at each surface is equal in extent, but opposite in direction (Fig. 1).

If the denser medium is bounded by oblique surfaces, the deviation at the second surface does not restore the ray to its original direction, but it still more increases the alteration of its direction (Fig. 2).

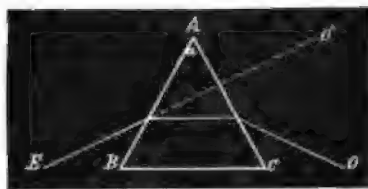


FIG. 2.—Refraction through a denser medium having oblique surfaces. At each surface the ray is bent toward the base of the figure.

**Index of Refraction.**—The deviation of the ray from its course depends upon the difference in the density of the two media.

A ray passing obliquely from one medium into another of the *same* density is not bent from its course. The relative resistance of a substance to the passage of light is expressed by its *index of refraction*. The absolute index of refraction is its resistance as compared with vacuum; but as there is very little difference between the indices of refraction of air and of vacuum, air is considered as 1 for all calculations in lenses.

As the difference in the density of the two media increases, the ray is bent more sharply from its course, and the angle it forms with the perpendicular after refraction by a denser medium is proportionably smaller than the angle formed by the ray before refraction.

The angle formed by the ray with the perpendicular to the surface of the second medium is called *the angle of incidence*—angle *I*. The angle formed by the ray with the perpendicular after refraction is called *the angle of refraction*—angle *R*. The sine of the angle of incidence, divided by the sine of the angle

of refraction, gives the index of refraction. Glass used in the manufacture of spectacles has an index of refraction of about 1.53.

**Prisms.**—A *prism* is a portion of glass or other refracting substance bounded by two plane surfaces which are inclined to each other, forming an angle, which is called the *refracting angle*, or simply the *angle* of the prism (Fig. 2, *a*), and is expressed in degrees. Prisms are often designated by the numbers of degrees in the refracting angle.

The sides of the prism converge to a thin edge at one extremity, called the *apex* (Fig. 2, *A*); at the other extremity they diverge from each other and form the *base* (Fig. 2, *B-C*).

**Refraction Through a Prism.**—If a ray of light from an object (Fig. 2, *O*) passes through a prism the refractive index of which is greater than air, the deviation is always from the apex toward the base of the prism.

To the eye of an observer placed at the other side of the prism (Fig. 2, *E*) the refracted ray seems to come from the direction of the apex (Fig. 2, *O'*), since a ray is projected backward over the course given to it by its last refraction, and a single object appears double if, with both eyes open, a prism of sufficient strength is placed before one of them. The angle which the ray in this last direction forms with the ray in its original direction is called the *angle of deviation*.

When one eye, on account of muscular weakness, is unable to direct its visual line to the point of fixation, a prism will alter the direction of the ray from the point of fixation so that it coincides with the visual line of the weaker eye. The refractive properties of a prism are further utilized to test the strength of the ocular muscles (see page 80), to neutralize the diplopia caused by abnormal deviation of the visual line—for example, in strabismus and to detect malingerers who feign monocular blindness (see page 547).

**Angle of Deviation.**—The angle of deviation is the angle formed by the incident ray with the refracted ray. The amount of this angle is somewhat more than one-half of the refracting angle of the prism for all prisms between  $1^{\circ}$  and  $10^{\circ}$ , but for

practical purposes the two may be considered equal. Above this the deviation rapidly increases.

When the angle of incidence, formed by a ray in the interior of a prism, amounts to  $40^{\circ} 49'$ , the angle of refraction equals  $90^{\circ}$ ; the angle of deviation, the difference between the two, then equals  $49^{\circ} 11'$ . When the refraction which takes place at each surface of a prism is equal, the minimum amount of deviation is present. When the ray is perpendicular to one surface, the angle of incidence at the second surface equals the angle of the prism; the deviation is greater in this case,



FIG. 3.—Deviation produced by a prism:  $I$ , Angle of incidence;  $R$ , angle of refraction;  $D$ , angle of deviation;  $R + D = I$ ;  $D$  equals in weak prisms about  $\frac{1}{2}$  of  $R$  (Jackson).

as all the refraction takes place at one surface. A table of the minimum deviation of prisms is given on page 21.

**Numbering of Prisms.**—The designation of prisms by their angular deviation, instead of by their refracting angles, was urged by Dr. Edward Jackson, of Denver, before the Ninth International Medical Congress. Two methods of accomplishing this have been proposed:

**Dennett's Method; The Centrad.**—Dr. William S. Dennett's calculation has for its base an arc called the *radian*, whose length equals the radius of its curvature. Such an arc equals  $57.295^{\circ}$ . A prism which will produce an angular deviation of the one-hundredth part of this arc is called *one centrad*. The deviation of such a prism would, therefore, be  $0.57295^{\circ}$ . The merit of this method consists in the uniformity of the deviation, 10 centrads having exactly 10 times the deviation of 1 centrad. The deviations are so many hundredths of the radius measured on the arc.

**Prentice's Method; The Prism-diopter.**—Mr. Charles F.

Prentice proposes, as the standard of deviation, a prism which shall deflect a ray of light 1 centimeter at a plane 1 meter distant—that is, the hundredth part of the radius measured on the tangent. This he calls the *prism-diopter*. The value of the centrad and prism-diopter will be given below (see table).

There are two practical advantages connected with the method of Mr. Prentice which also can be applied to the centrad. The prismatic deviation of a decentered lens may be very readily found, as Prentice has shown by the following rule: If a lens be decentered 1 centimeter, the prismatic deviation of the lens will be equal to as many prism-diopters as the number of diopters in the lens. Thus, if a 4-diopter lens be decentered 1 centimeter, the prismatic deviation will be 4 prism-diopters, or 4 centrads, since centrad and prism-diopter almost exactly equal each other. The same lens decentered  $\frac{1}{2}$  centimeter would produce 2 prism-diopters or centrads of deviation.

*Table of relative values of centrads and prism-diopters,  
prepared by James Wallace.*

Centrads.		Prism-diopters.		Refracting angle of prism required.
1	. . . . .	1	. . . . .	1.06°
2	. . . . .	2.0001	. . . . .	2.16°
3	. . . . .	3.0013	. . . . .	3.24°
4	. . . . .	4.0028	. . . . .	4.32°
5	. . . . .	5.0045	. . . . .	5.40°
6	. . . . .	6.0063	. . . . .	6.47°
7	. . . . .	7.0115	. . . . .	7.54°
8	. . . . .	8.0172	. . . . .	8.62°
9	. . . . .	9.0244	. . . . .	9.68°
10	. . . . .	10.0333	. . . . .	10.73°
15	. . . . .	15.114	. . . . .	16.1°
20	. . . . .	20.270	. . . . .	21.13°
40	. . . . .	42.288	. . . . .	39.0073°

The prisms represent the minimum deviation with an index of refraction of 1.53.

The relation to the meter angle (page 51) is also very simple. One-half the interpupillary distance is the sine of the meter angle. The ratio of this to the point of fixation

in hundredths gives nearly the number of prism-diopters, or centrad of deviation, embraced in any number of meter angles. For example, if the interpupillary distance is 60 mm., one-half of this is 30; assuming the amount of convergence to be 4 meter angles, 25 centimeters, or 250 mm., is the distance of the point of fixation. The deviation of the visual line then is 30 in 250, or 12 in 100 = 12 centrad, or 12 P. D. For small arcs the tangent and the sine agree very closely with the arc. Four meter angles of convergence then represent 12 centrad of deviation, or 12 prism-diopters.

**Rays of Light.**—Any luminous point diffuses light in all directions in straight lines called *rays*. As the rays proceed



FIG. 4.—Divergence of rays from a luminous source (Loring).

from the luminous source, those which diverge from one another become more widely separated (Fig. 4).

If a circular aperture 1 centimeter in diameter be made in a metal plate and a luminous point be placed at different distances from it,—for example, at 1 meter and at 10 meters,—the rays coming from 10 meters, which pass through the aperture, will be less diverging than those which come from 1 meter. A cone of light will pass through the aperture in each case, but the shape of it will be different according to the distance of the light from the aperture in the screen. When the round hole, 1 centimeter in diameter, is 1 meter distant from the point of light, the cone has a base 1 centimeter in diameter, and the apex is situated in the luminous point 100 centimeters distant. The rays have diverged 1

centimeter in traveling 100; the metal plate has cut off all other rays having a greater divergence. If the cone of light passes through the aperture and falls upon a distant wall, the cone will preserve the same proportions—viz., the base will be  $\frac{1}{100}$  of the altitude. If the wall be 5 times the distance of the screen from the light, a luminous circle 5 centimeters in diameter will be formed upon the wall. If, now, the light is removed to a point 10 meters from the screen (1000 centimeters), a cone of light is formed whose base is 1 centimeter and whose altitude is 1000. The rays which pass through the aperture have now only  $\frac{1}{10}$  of the divergence of the rays in the former case; the base of the cone is  $\frac{1}{1000}$  of the altitude. The cone of light will now form a circle on the wall 5 meters beyond the aperture, only 1.5 centimeters in diameter. If the point of light be at a very great distance, there will be



FIG. 5.—Rays diverging from the candle *A* pass through the aperture in the screen *S*, and form the cone of light whose base is the distance *a a'*. Rays from a more distant candle, *B*, having a greater divergence than *b b'*, are intercepted by the screen *S* (Wallace).

no difference in the size of the luminous circle and the aperture in the screen; the size of the circle remains about 1 centimeter on the wall at 5 meters from the screen. The rays, therefore, have a nearly parallel direction. This is shown in Fig. 5.

Rays which enter the pupil of the eye from a point 6 meters distant have so little divergence that they may be considered parallel. The average size of the pupil being 4 mm., the divergence is only  $\frac{4}{80000}$ . All rays diverging more widely than this are excluded by this width of the pupil.

The relation to the eye of rays diverging from 6 meters or coming from an infinite distance is practically identical, but



for lenses of long focal distance and large aperture an infinite distance is required in order to obtain parallel rays. Thus the sun and stars are so remote that the rays coming from them have no appreciable divergence, and they are considered parallel.

**Parallel Rays.**—Parallel rays must emanate, as has been explained before, from a distant object. They are brought together by a lens at its principal focus. Conversely, rays which diverge from the principal focus of a lens are parallel to one another after being refracted by the lens.

**Divergent Rays.**—Divergent rays emanate from an object nearer than infinity. A greater refractive power must be exercised to bring them together at the same distance behind a lens than is required for rays which are parallel; consequently, divergent rays are united at a point farther than the principal focus. The nearer the point of divergence lies to the lens, the farther away from the lens is the point where the rays converge to a focus.

**Convergent Rays.**—Convergent rays do not exist in nature. Only such rays are convergent which have passed through a convex lens or have been reflected from a concave mirror.

**Significance of the Different Rays.**—The refraction of the eye is determined by the character which the rays must have in order to be brought to a focus on the retina.

An *emmetropic eye*, with relaxed accommodation, requires rays to be parallel in order that they shall meet on the retina.

A *myopic eye* requires the rays to diverge from some near point in order to meet on its retina.

A *hyperopic eye* requires rays which already have convergence to some point in order to unite them on its retina.

An emmetropic eye emits parallel rays.

A myopic eye emits convergent rays.

A hyperopic eye emits divergent rays.

**Lenses.**—A lens is a portion of glass or other transparent substance bounded by two curved surfaces, or by one curved surface and one plane surface. The curved surfaces are

convex, elevated in the center, and thin at the edge; and the concave, hollowed out in the center and thick at the edge.

A lens may be regarded as a series of prisms with the refracting angles increasing in value from the center toward the periphery.

In a *convex lens* the bases of the prisms are directed toward the center of the lens, and rays, therefore, are refracted toward the axis which passes through the center. In a *concave lens* the bases of the prisms are directed away from the center, and rays, therefore, are refracted away from the axis. As the angles increase from the center outward, the peripheral rays will be refracted more than the central rays. The result of

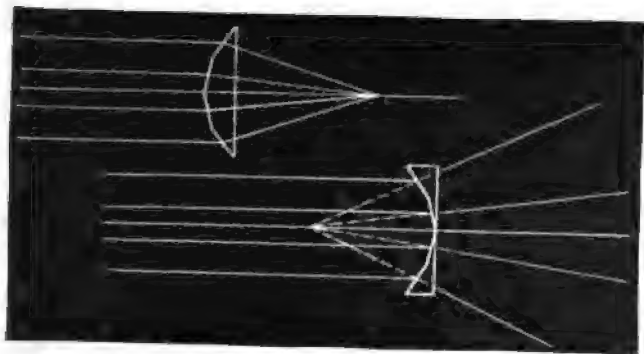


FIG. 6.—Lenses as prisms.

this is that in a convex lens the rays after refraction converge to the same point, the increased bending of the more peripheral rays just sufficing to compensate for their greater distance from the axis. In a concave lens the rays diverge more widely as they pass through the peripheral parts of the lens, with the result of making them appear to have diverged from a common point.

**Focus of a Convex Lens.**—The point to which rays converge after refraction by a convex lens is called its *focus*.

**Principal Focus of a Convex Lens.**—The principal focus of a lens is the focus for parallel rays. As the most distant rays are only parallel, never convergent, the principal focus is the shortest focus, unless the lens be combined with

another convex lens or concave mirror. Rays diverging from the principal focus of a lens are rendered parallel after passing through the lens, and come to a focus at an infinite distance.

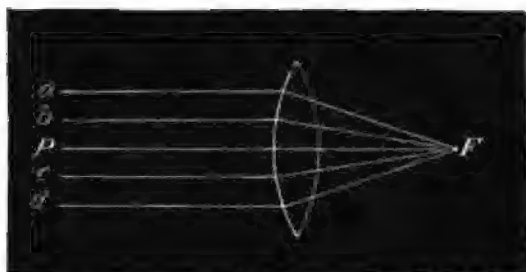


FIG. 7.—Principal focus of a convex lens. The parallel rays *a*, *b*, *c*, *d* are refracted by the lens so as to unite at the point *F* on the axis *P*; the ray *P* undergoes no refraction. *F* is the principal focus.

**Conjugate Focus of a Convex Lens.**—When rays diverge from any point nearer than infinity, they are brought together at a point on the other side of the lens farther than the principal focus. The point from which rays diverge and the point to which they converge are called *conjugate foci*. As the point of divergence approaches the lens the point of convergence recedes; when the point of divergence is at twice the focal distance of the lens, the point of convergence is at

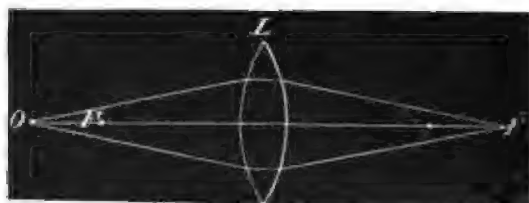


FIG. 8.—Conjugate focus of a convex lens. The two dots in the axis represent the principal foci, one being marked *F*. Rays diverging from *O* converge after refraction to the point *F'*, farther than the principal focus. Rays from *F'* also converge after refraction to *O*. *O* and *F* are conjugate foci.

an equal distance on the other side. The *conjugate foci* are now equal.

As the point of divergence approaches still closer the point

of convergence is at a greater distance, until, when the point from which the rays diverge is at the principal focus, the rays converge at an infinite distance.

Rays diverging from either of these points converge toward the other. When rays diverge from a point whose distance is equal to, or greater than, the principal focus, the conjugate focus is *positive*. When the distance is less than the principal focus, the conjugate focus is *negative*.

**Virtual Focus of a Convex Lens.**—When rays diverge from some point nearer to a lens than its principal focus, the rays after refraction still continue divergent. These divergent rays, if traced backward, would meet in a point on the same side of the lens from which they diverged. This point is called

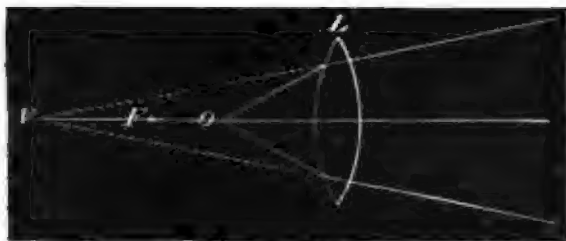


FIG. 9.—Virtual focus of a convex lens. Rays from the point  $O$ , less than the principal focal distance, diverge after refraction as if they came from the point  $V$ .  $V$  is the virtual focus of  $O$ .

a *negative*, or *virtual*, focus, because the rays do not really meet here, but are given a direction by the lens as if they had diverged from this point (Fig. 9). Therefore the point from which rays diverge and the point to which they converge are focal points.

**Foci of Concave Lenses.**—The foci of concave lenses for parallel or divergent rays are virtual, or negative. They are the points from which the rays seem to diverge after passing through the lens.

**Principal Focus of a Concave Lens.**—When parallel rays fall upon a concave lens they are rendered divergent. If these rays be traced backward, they will seem to have diverged from a point near the lens. This point is the *principal focus* (Fig. 10).

**Conjugate foci of concave lenses** are also virtual and found in a similar manner.



FIG. 10.—Principal focus of a concave lens. Parallel rays  $a, b, d, e$ , after refraction by the concave lens  $L$ , are rendered divergent as if they came from the point  $F$  on the axis  $c$ . The ray  $c$  is not refracted.  $F$ , the principal focus of a concave lens, is virtual.

### Formation of Images by a Lens : Optical Center.—

In the lens (Fig. 11) the point  $O$  on the axis is called the

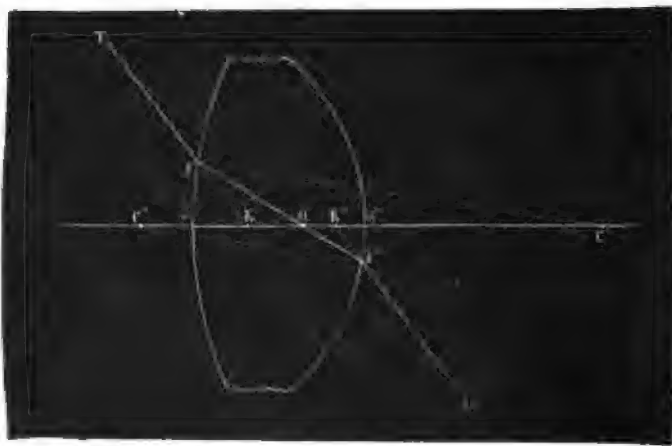


FIG. 11.— $O$ , Optical center of lens. The point  $C''$  is the center of curvature for the surface  $S''$ . The point  $C'$  is the center of curvature for the surface  $S'$ . A ray passing from  $C''$  to  $C'$  would be perpendicular to both surfaces. It would pass through without deviation. This ray is called the *axial ray*, or *axis*.

The radii  $C''J''$  and  $C'J'$ , being parallel, a ray in the lens passing in the direction  $J'J''$  must form equal angles at the two surfaces. The point where this ray intersects the axis is the *optical center* (Landolt).

*optical center.* Any ray passing through this point is refracted equally at both surfaces, since it forms equal angles with the

radii of the two surfaces. The direction of the ray is, therefore, the same after refraction by the second surface as it was before refraction by the first. For thin lenses it may be said that any ray directed to the optical center passes through without deviation. These rays are called *secondary axes*.

The ray drawn from any point in an object to the optical center of a lens gives the line on which the image of the point is to be found. A ray from the same point in the object, passing parallel to the axis of the lens, would be refracted

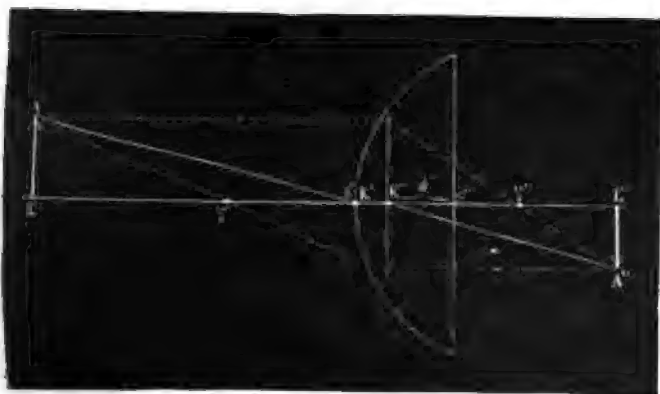


FIG. 12.—Position and size of image formed by convex lens. The ray  $A, K'$ , from the point  $A$ , being directed to the optical center of the lens, continues its course in a parallel direction,  $K'' A''$ . Another ray passing from  $A$  parallel to the axis  $L', L''$ , is refracted through  $\phi''$ , the principal focus, and, intersecting the ray  $A K'' A''$ , determines the position of the image of the point  $A$ . Still another ray passing from  $A$  through the anterior principal focus  $\phi'$ , after refraction, is parallel with the axis  $L' L''$ , and meets the other rays in the point  $A'$  (Landolt).

through the principal focus of the lens, since the principal focus is the focus for parallel rays (Fig. 12).

In order to find the position and size of an image formed by a lens it is only necessary to draw two lines from each extremity of the object: one passes through the optical center of the lens, and the other, parallel with the axis of the lens, would be refracted to the principal focus. The *position of the image* is found at the points where these lines intersect.

The size of the image is proportional to the size of the object as the distance of the image from the optical center is

to the distance of the object from the optical center. When the object is situated at a greater distance from the lens than its principal focus, the image is a real, inverted one.

In the figure (Fig. 13)  $OB$  is the object; the rays diverg

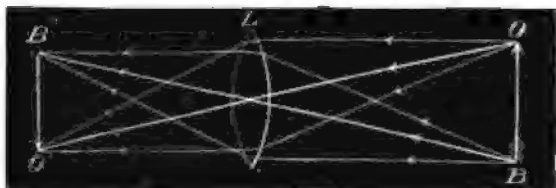


FIG. 13.—Image formed by a convex lens:  $OB$  is the object;  $O'B'$  is the inverted image.

ing from  $O$  intersect in  $O'$ , which is the position of the image of the point  $O$ . Similarly the rays from  $B$  unite in  $B'$ , the position of the image of the point  $B$ ;  $B'O'$  is the image of  $OB$ .

When the object is situated nearer to the lens than its principal focus, the image is a virtual, erect one.

The *virtual* image of a *convex* lens appears to be at the

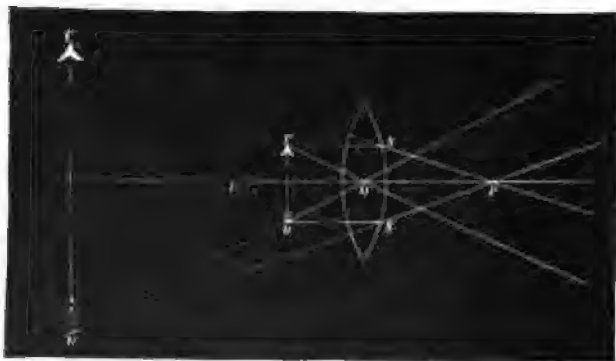


FIG. 14.—Virtual image of a convex lens:  $CD$  is the object;  $C'D'$  is the virtual image, erect and magnified.

point from which the rays refracted by the lens seem to have diverged (Fig. 14). From the point  $C$ , of the object  $CD$ , the ray  $CS$  is parallel to the axis. It, therefore, is refracted to the principal focus,  $P$ . The ray  $CO$  passes through un-

changed. By projecting these rays backward they meet in  $C'$ , the image of the point  $C$ . The rays from the point  $D$  seem to have diverged from  $D'$ . An enlarged, *erect* image is thus formed in  $C' D'$ .

The image formed by a *concave* lens is mostly *virtual* and diminished. Two rays, proceeding from a point  $O$ , in the object, one parallel to the axis, which seems, after refraction, to have diverged from the principal focus, and is traced backward, and the other, which is directed to the optical center, at their intersection, denote the position of this point in the image (Fig. 15).

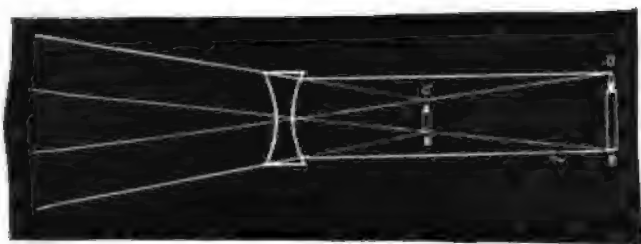


FIG. 15.—Virtual image of a concave lens:  $O' B'$  is the virtual image of the candle,  $O B$ , erect and diminished in size.

**Focal Distance of a Lens.**—The distance from the optical center of a lens to the focal point is called the *focal distance*.

The length of this depends upon the radii of curvature of the surfaces of the lens and on its index of refraction. Representing the radius by  $r$ , the index of refraction of the lens by  $n$ , that of air being 1,  $F = \frac{r}{2(n-1)}$  is the formula for obtaining the focus of a bispheric convex or concave lens. The formula for a planospheric lens is  $F = \frac{r}{n-1}$ , as the refraction is effected at one surface.

**Numeration of Lenses.**—The refractive power of a lens is the inverse of its focal distance. If the refractive power of a lens whose focal distance is 1 meter is represented by 1, then a lens whose focal distance is 2 meters has only one-half the refractive power of the first, since the rays are not bent so



sharply by the second lens. Again, if a lens bends rays so sharply that they meet the axis at  $\frac{1}{2}$  meter distance, its refractive power is twice that of a lens of 1 meter focus.

The focus of a biconvex lens (with equal radii), made of glass with an index of 1.50, has the same length as the radius of curvature.

$$F = \frac{r}{2(n-1)} = \frac{r}{2(1.50-1)}$$

$$F = r.$$

Glass used in spectacle lenses has an index of 1.53, consequently—

$$F = \frac{r}{1.06}$$

$$r = 1.06 F.$$

In the old system the lenses were marked according to their radii of curvature in Paris inches, and the focal distance was somewhat less than the radius of curvature. As all the lenses in use had longer focal distances than 1 inch, they were fractions of the refractive power of a lens of 1 inch focus—viz.,  $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{8}$ ,  $\frac{1}{16}$ , etc.

In 1867 Nagel proposed to number lenses by their refractive power. By adopting as a standard a lens of longer focal distance than 1 inch,—viz., 1 meter (40 inches),—the greater number of lenses are made multiples of refractive power of the standard, and are based on their focal lengths in meters and fractions of a meter, instead of being based on their radii of curvature.

The term *dioptr* was proposed by Monoyer for a lens of 1 meter focus. A lens of 2 meters focus is only  $\frac{1}{2}$  the refractive power, or 0.50 D. The present scale of lenses comprises a series from 0.12 D to 22 D. Between 0.12 D and 1.25 D the lenses have an interval of 0.12 D. From 1.25 D to 5 D the interval is 0.25 D; from 5 to 8 D an interval of 0.50 D; from 8 to 18 D an interval of 1 D; and from 18 to 22 D the interval is 2 D. This uniformity in the intervals between the lenses is an important advantage over the old system, in which the lack of uniformity in this respect was a conspicuous feature.

To find the focal length of any lens in the dioptric system

divide 1 meter, or 100 centimeters, by the number of diopters :

thus the focal length of a lens of 5 D is  $\frac{100}{5} = 20$  cm.

	No. of lens in diopters.	Focal distance in millimeters.	Focal distance in English inches.	Nearest corre- sponding lens in old system.
Interval of 0.12 D.	0.12	8000	314.96	144
	0.25	4000	157.48	
	0.37	2666	104.99	
	0.50	2000	78.74	
	0.62	1600	62.99	
	0.75	1333	52.5	72
	0.87	1143	44.99	60
	1	1000	39.37	48
	1.12	888	34.99	42
	1.25	800	31.5	36
	1.5	666	26.22	30
	1.75	571	22.48	24
	2	500	19.69	20
	2.25	444	17.48	18
	2.50	400	15.75	16
Interval of 0.25 D.	2.75	363	14.31	15 or 14
	3	333	13.12	13
	3.25	308	12.11	12
	3.50	285	11.25	11
	3.75	267	10.49	10
	4	250	9.84	9
	4.25	235	9.26	8
	4.50	222	8.74	
	4.75	210	8.29	
	5	200	7.87	7
Interval of 0.5 D.	5.50	182	7.16	
	6	166	6.54	6
	6.50	154	6.06	
	7	143	5.63	5
	7.50	133	5.25	4.5
	8	125	4.92	
	9	111	4.37	
	10	100	3.94	4
Interval of 1 D.	11	91	3.58	3.5
	12	83	3.27	3.25
	13	77	3.03	3
	14	71	2.8	2.75
	15	66	2.64	2.5
	16	62	2.44	
	17	59	2.32	2.25
Interval of 2 D.	18	55	2.17	2
	20	50	1.97	
	22	45	1.79	

In the old system the lenses are ground with a radius of curvature in Paris inches. The focal length is almost exactly the same in English inches as the radius of curvature is in

French inches. The English inch = 25.4 mm.; the French inch = 27.07 mm.;  $25.4 \times 1.06 = 26.92$ .

In column 3 of the table the focus is given in English inches, as it is customary to compare the French lenses with the diopters by their focal length in English inches. A lens of 1 diopter has a focal length of 39.37 English inches. There is no lens in the old system which corresponds to it exactly. The nearest equivalent would be a lens of 40 inches.

The lenses used for spectacles are spheric and cylindric.

**Spheric Lenses.**—A spheric lens is represented by a section of a sphere, or of two sections of a sphere placed together



FIG. 16.—1. Biconvex lens. 2. Planoconvex lens. 3. Concavoconvex lens, convergent meniscus. 4. Biconcave lens. 5. Planoconcave lens. 6. Convexoconcave lens, divergent meniscus.

by their plane surfaces. Light passing through a spheric lens is refracted equally in all planes.

**Cylindric Lenses.**—A cylindric lens is a section of a cylinder parallel to its axis. Light passing through a cylindric lens is not refracted in a plane parallel to its axis, but in a plane perpendicular to the axis; rays are rendered conver-

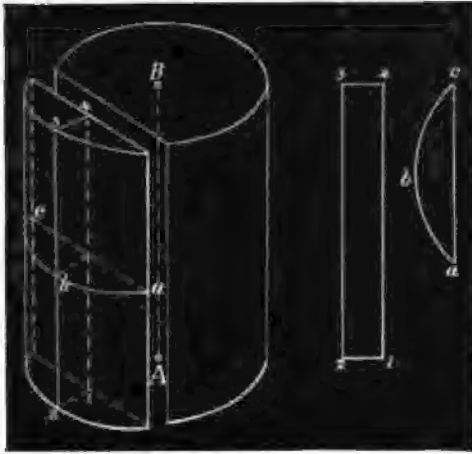


FIG. 17.—Convex cylindric lens, formed by a section of a cylinder parallel to its axis, which acts like a plane lens ( $t$ ,  $2, 3, 4$ ), in a direction parallel to the axis of the cylinder ( $A, B$ ), and like a convex lens ( $a, b, c$ ), in a direction perpendicular to the axis (Elschnig).

gent or divergent according as the cylinder is convex or concave (Figs. 17, 18).

Convex lenses are designated +; concave lenses, -.

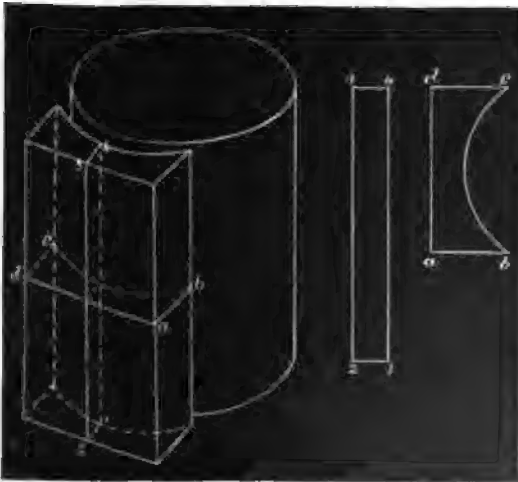


FIG. 18.—Concave cylindric lens, formed from a solid cylinder; in a plane parallel to the axis it acts like a plane lens ( $r$ ,  $z$ ,  $\beta$ ,  $\delta$ ), but in a plane perpendicular to the axis like a concave lens ( $a$ ,  $b$ ,  $c$ ,  $d$ ) (Elschnig).

**Combination of Lenses.**—If two or more lenses are placed together, for example, + 2 diopters + 3 diopters, and + 4 diopters, the combination forms a dioptric power equal to their sum—viz., 9 diopters; such a combination has, if composed of thin lenses, a focal distance of  $\frac{100}{9} = 11$  centimeters. If these lenses are placed at their focal distance from an object, the rays coming from the object, after passing through the lenses, are parallel.

Two or more concave lenses placed together likewise produce a dioptric effect equal to their sum.

**Combination of Convex and Concave Lenses.**—If a concave and a convex lens of equal strength are placed together, they will neutralize each other so exactly that a distant object viewed through them will appear neither enlarged nor diminished, and there will be no prismatic deviation on gently shaking the lenses in a direction parallel to the surface.

Should they be unequal in strength, on shaking them an object (the edge of a wall or window frame is suitable) will be displaced toward the center of the lens if the concave is stronger, and away from the center if the convex is stronger. The value of the combination will be the difference between the strength of the two. For instance, a + 3 diopter and a - 2 diopter equal + 1 diopter; a + 2 diopter and a - 4 diopter = - 2 diopter.

A - 2-diopter lens gives to parallel rays a direction as if they came from a point 50 cm. away. Conversely, rays diverging from any near point may be represented by a concave lens, the principal focus of which equals that distance. Let rays, for example, diverge from a point 15 cm. away; they evidently are similar to parallel rays which have passed through a concave lens of 15 cm. focal distance,  $\frac{100}{15} = 6.66$  diopters.

If it is desired to find the conjugate focal distance of any lens for rays which diverge from 15 cm., 6.66 should be subtracted from the dioptric power of the lens; the remainder gives a lens the focal distance of which is the conjugate desired. If it is desired to find the conjugate focal distance of a 12-diopter lens for rays which diverge from 15 cm., 6.66 should

## Combination of Cylindric with Spheric Lenses 37

be subtracted from  $12 = 5.33$  diopters; 18.8 cm. is the conjugate focal distance.

**Combination of Cylindric Lenses with Spheric Lenses.**—A cylindric lens is curved only in the direction *perpendicular to its axis*; rays which enter the lens are refracted in this plane to the focus of the lens exactly as in the case of a spheric lens.

In the opposite direction, that is, *parallel to its axis*, the surface of a cylindric lens is flat; rays entering are not refracted in this plane, but pass through unchanged. The effect of a cylindric lens placed in front of the eye is to increase or diminish its refraction in the direction at right angles to its axis, but in the opposite direction the refractive power is unchanged (see Figs. 17 and 18).

A convex 4-diopter cylindric lens, with its axis in a vertical direction (written  $+4$  D cyl., axis  $90^\circ$ ), increases the refraction in the horizontal direction 4 diopters, but does not alter the refraction in the vertical direction. The horizontal plane is expressed by the term *horizontal meridian*; the vertical plane by the term *vertical meridian*.

A concave cylindric lens of 4 diopters, with its axis horizontal (written  $-4$  D cyl., axis  $180^\circ$ ), diminishes the refraction of the vertical meridian 4 diopters, but does not affect the refraction of the horizontal meridian.

A convex lens of 3 diopters, combined with a convex cylindric lens of 2 diopters, with its axis vertical (written  $+3$  D  $\bigcirc$   $+2$  D cyl., axis  $90^\circ$ ), adds to the horizontal meridian  $+5$  diopters, but to the vertical meridian only 3 diopters.

The combination of a convex spheric lens with a concave cylindric lens has the following effect: In the direction parallel to the axis of the cylinder the combination equals the full refraction of the spheric; in the direction at right angles to the axis of the cylinder the refraction is equal to the difference between the two lenses. If the convex spheric is stronger than the concave cylinder, the difference is still represented by a convex glass. For example,  $+2$  D sph.,  $\bigcirc -1.50$  D cyl., axis  $180^\circ = +0.50$  D sph.,  $\bigcirc +1.50$  D cyl., axis  $90^\circ$ , because  $+2$  D in the meridian of  $180^\circ$  is not diminished, but

in the meridian of  $90^\circ$  it is reduced to  $+0.50$  D. Now,  $+0.50$  D sph. produces this amount of refraction at  $90^\circ$ , and supplies  $+0.50$  D of the requisite  $+2$  D at  $180^\circ$ , leaving  $+1.50$  D to be supplemented by a cylindric lens with its axis at  $90^\circ$ .

In place of writing  $+2$  D sph.  $\ominus -1.50$  D cyl., axis  $180^\circ$ , a more simple expression would be  $+0.50$  D sph.,  $\ominus +1.50$  D cyl., axis  $90^\circ$ .

When, however, the concave cylindric lens is stronger than the convex spheric, the difference is represented by a concave lens, thus  $+3$  D sph.,  $\ominus -6.50$  D cyl., axis  $180^\circ$ , signifies in the horizontal meridian convex  $3$  D, and in the vertical meridian concave  $3.50$  D. It is necessary to combine a convex with a concave lens in order to obtain this effect. The refractive power of this combination can be expressed in three different ways:

$+3$  D sph.,  $\ominus -6.50$  D cyl., axis  $180^\circ$ .

$-3.50$  D sph.,  $\ominus +6.50$  D cyl., axis  $90^\circ$ .

$+3$  D cyl., axis  $90^\circ$   $\ominus -3.50$  D cyl., axis  $180^\circ$ .

In the first combination  $+3$  D sph. gives the  $+3$  D necessary for the horizontal meridian, but increases the refraction of the vertical meridian  $3$  D instead of diminishing it; therefore the  $-6.50$  D cyl., axis  $180^\circ$ , expends  $3$  D of its refractive power in neutralizing the effect of the  $+3$  D sph., and with the remainder diminishes the refraction of the vertical meridian  $3.50$  D.

In the second combination,  $-3.50$  D sph.,  $\ominus +6.50$  D cyl., axis  $90^\circ$ , the concave spheric lens diminishes the refraction of the vertical meridian  $3.50$  D, but also diminishes the refraction of the horizontal meridian  $3.50$  D; as this already requires  $+3$  D, we must add  $+3.50$  D more to compensate for the concave spheric, making  $+6.50$  cyl., axis  $90^\circ$ .

In the third combination,  $+3$  D cyl., axis  $90^\circ$   $\ominus -3.50$  D cyl., axis  $180^\circ$ ,  $+3$  D cyl., axis  $90^\circ$  increases the refraction of the horizontal meridian without altering the refraction of the vertical meridian, and the  $-3.50$  D cyl., axis  $180^\circ$  diminishes the refraction of the vertical meridian without affecting the refraction of the horizontal.

With the combination of a convex spheric and cylindric

lens, *e. g.*, + 3 D sph.,  $\ominus$  + 2 D cyl., axis  $90^\circ$ , a concave 0.50 D cylinder with its axis at right angles to the axis of the convex cylinder, in this case at  $180^\circ$ , diminishes the refraction of the vertical meridian 0.50 D, the combination then equals - 2.50 D in the vertical meridian and + 5 D in the horizontal = + 2.50 D sph.,  $\ominus$  + 2.50 D cyl., axis  $90^\circ$ .

A convex cylinder + 0.50 D added to the same combination, with its axis at right angles to the axis of the first cylinder, that is, + 0.50 D cyl., axis  $180^\circ$  with + 3 D sph.,  $\ominus$  + 2 D cyl., axis  $90^\circ$ , increases the refraction in the vertical meridian + 0.50 D. The combination then equals + 3.50 D in the vertical meridian, + 5 D in the horizontal. This is obtained by + 3.50 D sph.,  $\ominus$  + 1.50 D cyl., axis  $90^\circ$ .

**Visual Angle.**—The apparent size of an object depends upon the size of the *visual angle*.

The visual angle is the angle formed by the lines drawn from the two extremities of an object to the nodal point of

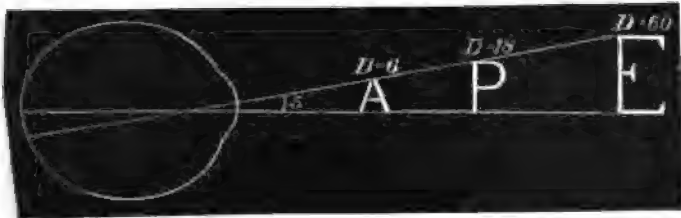


FIG. 19.—The visual angle.

the eye. The *nodal point* of the eye is analogous to the optical center of a lens. It is situated 15 mm. in front of the retina, and 7 mm. behind the cornea. Rays directed to this point pass through without deviation.

As the rays directed to the nodal point of the eye are not refracted, but continue the same course until they strike the retina, if lines are drawn from the extremities of an object through the nodal point of the eye, and continued until they fall upon the retina, the size of the retinal image of the object is obtained.

The figure shows that the object, in order to subtend the same angle, must be larger the farther it is removed from the



eye. The letter *A*, seen clearly at 6 meters, would have to be three times as large in order to be seen distinctly at 18 meters, and ten times as large in order to be seen clearly at 60 meters. The visual angle in the three cases remains the same.

**Retinal Image in Emmetropia.**—In the emmetropic eye the *nodal point* is situated 7 mm. behind the cornea and 15 mm. in front of the retina. The size of the retinal image is to the size of the object as the distance from the retina to the nodal point (15 mm.) is to the distance from the nodal point to the object. Therefore, if an object is situated at 1 meter distance (1000 mm.), its image will be  $\frac{15}{1000}$  of the size of the object.

**Retinal Image in Ametropia.**—In the hyperopic eye, the axis of which is shorter than that of the emmetropic eye, the retina is situated nearer the nodal point; the image is therefore smaller. In myopia the axis of the eye is longer; the retinal image is, therefore, larger.

**Visual Acuteness; Limit of Perception.**—An object 1 cm. in size, placed 1 meter distant from a normal emmetropic eye (that is, an eye without any error of refraction), is plainly visible. If this object is moved farther and farther away, it forms a progressively smaller visual angle, until a point is reached beyond which it cannot be perceived, owing to the diminutive size of the visual angle. The *limit of perception* has now been reached.

The angle which the object subtends at this distance from the eye represents the maximum *acuteness of vision*. An object twice the size would be seen distinctly at twice this distance. An object one-half the size could not be distinctly seen at more than half this distance. In general terms the size of the object denoting the acuteness of vision is always proportional to the distance.

**Normal Acuteness of Vision.**—Snellen determined the normal acuteness of vision to be the power of distinguishing letters subtending an angle of 5'. These letters are formed of strokes whose width is  $\frac{1}{5}$  the size of each letter; consequently they are seen under an angle of only 1'. The open-

ings in the letters and the spaces between contiguous strokes, as nearly as possible, are made to conform to the same angle.



FIG. 20.—Two of Snellen's test-types.

The relation of the size of the letter to the distance at which it should be discerned by a normal eye is expressed by twice the tangent of half the angle of  $5' = 0.001425$ . The size of a letter the perception of which constitutes normal vision at a given distance may be obtained by multiplying the distance by  $0.001425$ . At the distance of 1 meter the size of this standard letter is 1.42 mm. ( $0.001425 \times 1000$  mm.). At a distance of 6 meters the size of the letter required is 8.5 mm. ( $1.425 \times 6$ ). The size of the retinal image of a standard letter of 6 meters =  $\frac{1}{8000}$  of 8.5 =  $0.00124$  mm., and the strokes, or openings, being  $\frac{1}{5}$  the size, have an image of  $0.00025$  mm. A large number of people, after correction of their ametropia, have a visual acuity of 1.25 of normal, and therefore letters constructed on an angle of  $4'$  have been used for testing visual acuity. The retinal images of the strokes of such letters are  $\frac{1}{5}$  of  $0.00025 = 0.00005$  mm. The size of the cones of the macular region varies from  $0.0033$  to  $0.0036$  mm., showing a most interesting relation between the limit of perception and the anatomic structure of the retina.

#### ACCOMMODATION.

Inasmuch as the eye is inextensible, it cannot adapt itself for the perception of objects situated at different distances by increasing the length of its axis, but only by increasing the refractive power of its lens. Rays diverging from near objects are thus brought to a focus at the same distance as the rays diverging from remote objects. This power the eye possesses of adapting its refraction for different distances is called *accommodation*, and the change required in its optical adjustment is effected by the ciliary muscle in the following manner: The ciliary muscle, which lies between the sclera

and the ciliary processes, and which is attached posteriorly to the choroid tract by fibers known as the *tensor choroidea*, contracts. This contraction draws forward the choroid and ciliary processes, to which is attached the suspensory ligament of the lens or zonula of Zinn. Hence the zonula is relaxed, and the tension which it has exerted on the lens capsule is removed. The crystalline lens, a soft and elastic body, thus freed from compression, tends to assume a spheric

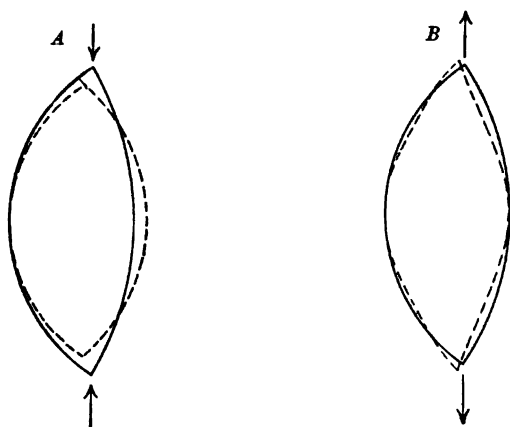


FIG. 21.—*A*, Accommodation according to Helmholtz. The dotted line represents the thicker form assumed by the lens when the traction of the zonula is diminished by the contraction of the ciliary muscle. *B*, Accommodation according to Tscherning. The unbroken lines show the lens at rest. The dotted lines show the change occurring during accommodation, supposed to be due to the traction of the zonula being increased by the contraction of the ciliary muscle. It will be seen that the increased dioptric power of the lens may be obtained either by relaxation of the zonula or by contraction (Cutler).

shape, bulges forward, and becomes more convex. It has, in effect, added to its anterior surface another convex lens. As the ciliary muscle contracts more vigorously, this added convex lens becomes stronger.

Tscherning holds a different view of the mechanism of accommodation, thus expressed by Colman Ward Cutler: Accommodation does not depend on a relaxation of the zonula of Zinn, but on its tension through the agency of the ciliary muscle, whereby the peripheral portion of the lens is

flattened and the curve of the anterior surface from an approximately spheric approaches a hyperboloid form.

If an emmetropic individual wishes to see an object situated, for example, 25 cm. distant, he must exercise his power of accommodation to such a degree that in effect he adds to his crystalline lens another lens of 4 diopters—*i. e.*, one having a focal length of 25 cm. Rays diverging from 25 cm. are thus given a parallel direction and are brought to a focus on the retina by the original refractive power of the eye.

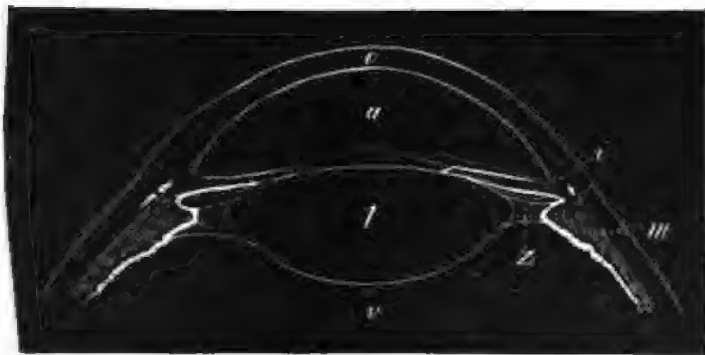


FIG. 22.—Increased convexity of the lens during accommodation. The solid white outline of the lens, *l*, shows its form when relaxed. The dotted line shows the increased curvature of the anterior surface during accommodation, and its advancement forward into the anterior chamber, *a*. *z* is the suspensory ligament; *m*, the ciliary muscle; and *i*, the iris (Landolt).

The degree of accommodation varies according to the distance of the object; it is not possible for an eye to be adapted for two different distances at one time. By means of the accommodation the eye is adjusted for all distances between its farthest and nearest point of distinct vision.

The **far point** of an eye, *punctum remotum*, is the point from which come rays having the least divergence, or toward which go rays having the greatest convergence that allows their focusing on the retina. From this point rays are focused on the retina with the ciliary muscle entirely relaxed, the refraction of the eye being at its minimum, *R*. This point, or its distance from the eye, is designated *r*.

The **near point** of an eye, *punctum proximum*, or *p*, is the

point from which come the most divergent rays that can be focused on the retina. These are focused with the ciliary muscle contracted to its fullest extent, and the eye in its condition of maximum refraction, expressed by  $P$ .

The **range of accommodation**, likewise denominated the *power* or *amplitude of accommodation*, is the difference between the refractive power of the eye accommodated for its far point and accommodated for its near point. This is expressed by  $A$ .  $A = P - R$ .

As the refractive power is the inverse of the focal distance, the refractive power of the eye, when accommodated for its far point  $r$ , is  $R = \frac{1}{r}$ . If we express the value of  $r$  in meters, we shall then have the refractive power of the eye expressed in diopters, a diopter being a lens of 1 meter focus. If  $r = 1$  meter,  $R = \frac{1}{1} = 1$  diopter = 1 D. If  $r$  is infinitely distant,  $R = \frac{1}{\infty} = 0$ .

In the same manner  $\frac{1}{p} = P$ , the refractive power of the eye when accommodated for its nearest point. If we obtain the value of  $p$  in centimeters and wish to know how many diopters it equals, we must divide 100 by the number of centimeters equal to  $p$ . Let  $p = 10$  cm., then  $P = \frac{100}{10} = 10$  D. If  $p$  is expressed in fractions of a meter, we obtain the same result: by dividing 1 by the value of  $p$ , in meters, 10 cm. =  $\frac{1}{10}$  of a m.  $P = \frac{1}{\frac{1}{10}} = 10$  D, or, in decimals,  $1 \div 0.1 \text{ m.} = 10$  D—that is, in order to focus rays from 10 cm., we require 10 times as much accommodation as is necessary to focus rays from 1 meter, and since an eye adapted to a distance of 1 meter exerts 1 diopter of accommodation, at a distance of  $\frac{1}{10}$  m., or 10 centimeters, it must exert 10 diopters of accommodation.

**To find the range of accommodation** we must first deter-

mine the far point. This is accomplished by means of test-letters held in front of the patient. If the patient has maximum acuity of distant vision,  $r$  is infinite [when  $R = \frac{1}{\infty} = 0$ ] or negative. If vision is less than normal at 6 meters, but is normal at 1.5 meters,  $r = 1.5$  meters;  $R$  then  $= \frac{1}{1.5} = 0.66$  D.

If distant vision becomes or remains distinct when a convex glass of 2 D is placed before the eye, then  $R = -2$  D; that is, the far point of such an eye is negative, a point behind the retina toward which rays converge. This condition is further discussed on page 149.

The *near point* is found by holding in front of the patient finely printed reading-matter, and measuring the nearest distance to his eye at which this is distinct. For this purpose large print may be reduced by photolithographing, so as to subtend the standard angle of  $5'$  at a distance of 25 cm. or less, and is usually arranged on suitably shaped cards.

The *formula for obtaining the range of accommodation* is  $A = P - R$ . If  $p$  is at 20 cm.,  $P = \frac{100}{20} = 5$  D, and  $r$  is at infinity,  $R = 0$ , then  $A = P = 5$  D. This is the case in emmetropia.

If  $p$  is at 10 cm.,  $P = \frac{100}{10} = 10$  D, and  $r$  is at 25 cm.,  $R = \frac{100}{25} = 4$  D, then  $A = 10$  D  $-$  4 D  $=$  6 D. This is the case in myopia of 4 D.  $P$  is greater than  $A$ .

If  $p$  is at 50 cm.,  $P = \frac{100}{50} = 2$  D, and  $r$  is negative,  $-25$  cm.  $R = \frac{100}{-25} = -4$  D.  $A = 2 - (-4) = 2 + 4 = 6$  D. This is the range of accommodation in a hyperope of 4 D, and equals the sum of  $P$  and  $R$ .<sup>1</sup>

The near point is closer to the eye in young life, while the

<sup>1</sup>  $p$  refers to the distance of the near point in centimeters.  $P$  refers to the refractive power of the eye in accommodation for  $p$ .  $r$  refers to the distance of the far point.  $R$  refers to the refraction of the eye when accommodated for  $r$ .

lens is soft; as age advances the lens becomes harder and the near point gradually recedes until, at about the age of seventy, the near point has reached infinity, and  $p$  and  $r$  then coincide, and there is no range of accommodation.

The failure of the accommodation due to age is termed *presbyopia*. This is more fully described under Presbyopia (see page 180).

The *range of accommodation* is nearly constant for the same age, so that if  $p$  is nearer than it should be, myopia may be

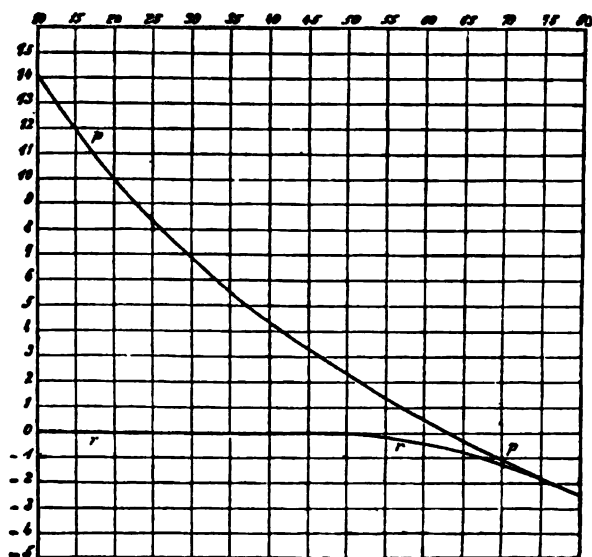


FIG. 23.—Diagram of the range of accommodation. The vertical column of figures on the left hand side indicates the diopters of accommodation. The horizontal line of figures at the top represents the ages. The curved line,  $p p$ , represents the refractive power of the eye at different ages, when accommodated for its near point. The line  $r r$  represents the refraction of the eye when relaxed for its far point. At fifty-five years it is supposed to become hyperopic;  $r$  then becomes negative (Landolt).

suspected, or if it is farther away than the average, hyperopia (Fig. 23). For this purpose the table given on page 47 is used, which records the average of  $P$  in diopters and  $p$  in centimeters for the different ages.

TABLE OF THE RANGE OF ACCOMMODATION.

10 years . . . . .	14 diopters	$p = 7$ cm.
15 " . . . . .	12 "	" = 8.3 "
20 " . . . . .	10 "	" = 10 "
25 " . . . . .	8.5 "	" = 12 "
30 " . . . . .	7 "	" = 14 "
35 " . . . . .	5.5 "	" = 18 "
40 " . . . . .	4.5 "	" = 22 "
45 " . . . . .	3.5 "	" = 28 "
50 " . . . . .	2.5 "	" = 40 "
55 " . . . . .	1.75 "	" = 55 "
60 " . . . . .	1 "	" = 100 "
65 " . . . . .	0.75 "	" = 133 "
70 " . . . . .	0.25 "	" = 400 "
75 " . . . . .	0 "	" = $\infty$

**Angle Gamma: Angle Alpha.**—The eye, in looking at any object, is directed forward in such a manner that the image is formed on the *macula lutea*. The eye is now said to "fix" the object. A line drawn from the object thus fixed to the macula lutea is called the *visual line*, or *visual axis*.

The point about which the eye revolves, in order to be brought into this position, is called the *center of rotation*, and has its position 14 mm. back of the cornea. The line which connects the object with the center of rotation is designated the *line of fixation*.

The *optic axis* is an imaginary line, passing through the center of the cornea and lens and the point of rotation, to the posterior pole of the eye—*i. e.*, a point usually between the macula and optic papilla.

If the macula lutea coincided with the posterior extremity of the optic axis, the visual line, line of fixation, and optic axis would also coincide. Generally, this coincidence does not exist. In emmetropia and hyperopia the optic axis passes to the inner side of the macula lutea, and the visual line and line of fixation then form angles with the optic axis. In Fig. 24  $AA'$  is the optic axis passing through the center of the cornea,  $C$ , the nodal points of the eye,  $K'K''$ , and the center of rotation,  $M$ .  $OF$  is the visual line connecting the object,  $O$ , with the fovea,  $F$ .  $OM$  is the line of fixation, drawn from  $O$  to the center of rotation,  $M$ . The eye, in order to fix  $O$ , has its



optic axis,  $A A'$ , deviated outward. The angle formed by the line of fixation,  $O M$ , with the optic axis  $A A'$ , is called the



FIG. 24.—Angle alpha and angle gamma:  $A A'$ , Optic axis;  $O F$ , visual line;  $O M$ , line of fixation;  $E L$ , major axis of corneal ellipse. The line of fixation does not correspond with the optic axis, but forms the angle  $O M A$ , angle gamma nearly equal to the angle  $O X A$ , formed by the visual line with the optic axis.  $O X A$  may be considered as the angle gamma. The visual line does not pass through the summit of the corneal curve,  $E$ , but forms with the axis of the cornea,  $E L$ , the angle  $O F E$ , the angle alpha (Landolt).

*angle gamma*,  $\gamma$ , or the angle formed by the visual line with the optic axis may be considered as the angle gamma.

The significance of this angle is that a person, while really fixing an object, seems to have a divergence of the visual lines—divergent squint. In estimating the degree of a divergent strabismus it is necessary to consider the value of this angle. The amount of the angle gamma is usually  $5^{\circ}$ , but it may reach as much as  $10^{\circ}$ . When the anterior extremity of the visual line passes to the inner side of the optic axis, the angle gamma is positive, or +; this is the usual condition in emmetropia and hyperopia. The convergence of the visual line exceeds the convergence of the optic axis by the amount of this angle. When the visual line coincides with the optic axis, there is no angle gamma. The visual line in high myopia sometimes passes to the outer side of the optic axis. The eyeball must then be deviated inward in order to fix on the object. This produces the effect of a convergent squint. It must be distinguished from squint; and if convergent strabismus also exists, the value of this angle must be deducted from the apparent squint. In this latter form of the angle gamma, where the anterior extremity of the visual line passes to the outside of the optic axis, the angle is negative, or -. The convergence of the visual line is less than the convergence of the optic axis by the amount of this angle.

The amount of this angle may be measured by placing the patient before the perimeter as if his field were to be taken. The eye is fixed on the central point, and a lighted candle is moved along the arc in a horizontal direction until its reflection is obtained from the portion of the cornea corresponding to the center of the pupil. The position of the candle may now be read from the arc in degrees, and represents the size of the angle gamma.

The apex of the cornea does not generally coincide with the center of the cornea, but is displaced laterally. The major axis of the corneal ellipse, represented in the figure by  $EL$ , therefore forms an angle with the visual line. The *angle alpha* is the angle formed by the visual line with the major axis of the corneal ellipse. It is *positive* when the major axis of the cornea passes to the outer side of the visual line; if the corneal axis passes to the inner side of the visual line, the angle alpha

is *negative*. In the figure the angle  $O X A$  is the *angle gamma*; the angle  $O X E$  is the *angle alpha*.

From what has been said it will be seen that the visual line is a secondary axis to the optical system of the eye. The oblique position of the refracting surfaces to the visual line may be the cause of an increased refraction in the horizontal meridian constituting astigmatism.

#### CONVERGENCE.

In the visual act of one eye the sensation conveyed to the brain is projected outward over the same course by which it arrived—that is, the object is referred to a position in the field of vision which it actually occupies. If the projection outward of the images of the two eyes is such that they overlies each other, the person will have single vision; if, however, they are projected in different positions, double vision is the result.

The images are projected in different positions when they are not formed on *identical points* of the two retinas. The *fovea centralis* being the most sensitive portion of the retina, the eye is naturally so directed toward an object that the image is formed upon it. The eye is then said *to fix* the object. The foveæ of the two eyes are identical points, and images formed on them are projected outward so as to overlie or fuse into each other; points at a corresponding distance to the right of each fovea, or to the left, or upward or downward, are also identical, and images formed on them produce but a single impression. Objects in the field of vision to the right of the point of fixation form a retinal image to the left of the fovea. Objects to the left of the point of fixation form an image to the right of the fovea (see Figs. 174, 175). All images formed on the retina to the right of the fovea are projected outward to the left. Those formed on the left of the fovea are projected to the right; in the same way those formed on the upper part of the retina are projected downward, and those formed on the lower part of the retina are projected upward.

The eyeballs are separated laterally, on the average, 64

mm. in adult eyes. In looking at a distant object, if the axes of the eyes are parallel, the images are formed on corresponding points of the retinas, but when the object is at some nearer point, the eyes must be turned inward in fixing the object, to compensate for their lateral separation. This function of the eyes is termed *convergence*.

The eyeball is rotated inward by the internal rectus muscle, so that its visual line is directed toward the object. This function is very closely associated with that of *accommodation*; one cannot act in any very great degree without the other also coming into play. The movement inward of the eye is measured by the angular deviation of the visual line, termed the *angle of convergence*.

The unit of convergence is the angle through which the visual axis moves to fix on a point 1 meter distant. This is termed *1-meter angle of convergence* (Nagel) (Fig. 25). If the object fixed is only  $\frac{1}{2}$  meter distant, the movement will be twice as great; it is then 2-meter angles. A point  $\frac{1}{3}$  of a meter would require 3-meter angles, and so on. Ten-meter angles of convergence mean that the eye is directed to a point only  $\frac{1}{10}$  of a meter distant.

**Meter Angle.**—In the figure,  $O$  and  $O'$  represent the centers of rotation of the two eyes;  $OO'$  is the distance between these points, termed the interocular distance. It is measured by the distance between the pupils during fixation for remote objects.  $OM$  is one-half this distance.

The line  $CM$  is perpendicular to  $OO'$ . When the object is



FIG. 25.—Meter angles of convergence (Landolt).

situated on the line  $CM$ , the convergence of each eye is equal. When the visual lines  $JO$  and  $JO'$  are parallel, the angle of convergence is *nil*; when, however, the visual lines are directed to  $C'$ , 1 meter distant,  $OJ$  has deviated to  $OC'$ .  $JO'C'$  is the angle through which the visual line has moved to fix on  $C'$ . This is 1-meter angle of convergence.

$CM$  being parallel to  $JO$ ,  $OC'M$  is equal to  $JO'C'$ .

In the right-angled triangle  $OC'M$ ,  $OM$  equals one-half the interocular distance.

$OC'$  = the distance of the point of fixation.

$\frac{OM}{OC'} =$  the sine of the angle  $OC'M$ .

The average interocular distance is 64 mm.  $OM = \frac{1}{2}$  of 64, or 32 mm.  $OC'$  is 1 meter distant.

$\frac{OM}{OC'} = \frac{32}{1000} = 0.32 =$  the sine of 1-meter angle. This corresponds to  $1^\circ 50'$ .

If the eye is directed to a point  $\frac{1}{2}$  meter distant,  $C''$ , the visual line will deviate twice as much—that is, it deviates 32 mm. at  $\frac{1}{2}$  meter distance. If the point of fixation is only  $\frac{1}{10}$  of a meter distant, the amount of convergence will equal 10-meter angles.

To find the value of this in degrees we employ the same formula as above:

$\frac{OM}{OC^{10}} =$  sine of angle  $OC^{10}M$ .  $OM = 32$ .  $OC^{10} = \frac{1}{10}$

meter = 100 mm.  $\frac{32}{100} = 0.32$ , the sine of angle of convergence, =  $18^\circ 40'$ .

The value of the meter angles in degrees is obtained very nearly by multiplying  $1^\circ 50'$  by the number of meter angles. The value of the meter angle varies with the interocular distance, and as there is considerable difference in this distance, a separate calculation is necessary for each individual.

A more simple method of determining the value of the meter angle is to find its relation to the centrad. The centrad is a prism which deviates a ray the  $\frac{1}{100}$  part of the radius, measured on the arc (see page 20). The deviation of the meter angle is measured on the sine. For the angles obtained, the sine and arc are almost equal.

One-meter angle equals a deviation of 32 mm. (the average distance between the centers of rotation of the eyes being 64 mm.) at 1 meter distance = 32 in 1000 mm., or 3.2 in 100 = 3.2 centrads. One centrad =  $0.57295^\circ$ ; 3.2 centrads =  $1^\circ 50'$ . Ten-meter angles equal a deviation of 32 mm. in  $\frac{1}{10}$  meter,

100 mm., 32 in 100, or 32 centrad =  $18^{\circ} 20'$ . A 32-centrad prism not only gives us the value of 10-meter angles of convergence, but, placed before the eye with the base inward, it takes the place of 10-meter angles of convergence, so that the eye, without any convergence, would see an object on the line  $C' M$ , 10 centimeters distant, as if it were situated at a remote distance.

The convergence becomes *greater* as the point of fixation approaches *nearer*. The number of meter angles is, therefore, inversely proportional to the distance expressed in meters. We thus designate the convergence in terms which indicate the same number of units of convergence as the diopters of accommodation necessary for the same distance. An emmetrope, in looking at an object  $\frac{1}{4}$  meter distant, would employ 4-meter angles of convergence and 4 diopters of accommodation.

The **amplitude of convergence** is the number of meter angles of convergence which the eyes can call into action. It is measured from the *far point of convergence* to the *near point of convergence*.

The far point of convergence is the point to which the visual lines are directed when the convergence is relaxed to its utmost; the near point of convergence is the point to which the visual lines are directed when the convergence is at its maximum. If in the minimum degree of convergence the visual lines are parallel, the far point of convergence will be at an infinite distance. Usually the visual lines actually diverge forward at the minimum of convergence, constituting an outward squint, and converge by their posterior extremities toward a point behind the eyes. When this is the case, the far point and a portion of the amplitude of convergence are negative. In some cases, with the convergence relaxed to its fullest extent, the visual lines still deviate inward, constituting an internal squint. The convergence will in such a case always be entirely positive.

**Relation between Accommodation and Convergence: Relative Accommodation.**—While the two functions of convergence and accommodation, as has already been

stated, are closely associated, there is still some independence of action. In other words, it is possible to accommodate several diopters without any convergence and to converge several meter-angles without accommodation. If the visual axes converge to a given point, the accommodation may be increased to a certain limit. The increased amount of accommodation exercised under these circumstances is measured by the ability to overcome concave glasses while the object still remains distinctly in view, and is denominated *the positive part of the relative accommodation*. It is also possible, while the visual lines converge for a given near point, to relax the accommodation from its association with that degree of convergence by placing convex glasses before the eyes, the object still remaining distinctly in view. This relatively diminished amount of accommodation is called *the negative part of the relative accommodation*. That convergence may be altered while the same effort of accommodation is maintained is demonstrable by placing a prism with its base inward before one eye, which then rotates outward, in order that the object may be seen singly, this object at the same time being perfectly distinct. Evidently the same effort of accommodation has been maintained, although the convergence of the visual axes is altered. At the far point of accommodation and convergence the accommodation has somewhat more play; at the near point, however, convergence has much the larger movement. The amplitude of convergence does not always diminish with age, as does the accommodation. Some persons, however, have a diminished convergence power or endurance, owing to changes in the ocular muscles similar in kind, though less in degree, to the senile changes which usually occur in other parts of the muscular system.

## CHAPTER II.

### EXAMINATION OF THE PATIENT AND EXTERNAL EXAMINATION OF THE EYE; FUNCTIONAL TESTING.

A SYSTEMATIC method of examination of each case should be practised in order to secure the preservation of careful records. For this purpose the following order of examination may be used:<sup>1</sup>

Name and residence.

Age, sex, race, married, single, or widowed.

Family history: hereditary tendencies; general and ocular health of parents, brothers, sisters, etc.

Personal history: children, their general and ocular health; miscarriages; menopause; former illnesses; syphilis; gonorrhea; injuries.

Occupation: relation of work to present indisposition.

Habits: brain use; tobacco; alcohol; narcotics; sexual.

Date and mode of onset and supposed cause of present trouble; outline of its course.

Organs of digestion: teeth; tongue; stomach; bowels.

Organs of respiration: nose; throat; lungs.

Organs of circulation: heart; pulse; blood.

Kidneys: examination of urine.

Abdominal organs: liver; spleen.

Organs of generation; menses; leukorrhea; uterine disease.

Nervous system; intelligence; evidences of hysteria; hallucinations; sleep; vertigo; gait; station; tendon- and muscle-jerks; paralysis; tremor; pain; subjective sensations; convulsions; headaches and their position.

Eyes: previous attacks of inflammation; injuries; infections; ocular palsy or squint; amblyopia; previous use of glasses; ability to use eyes.

Direct inspection and examination of eyes: inspection of the skull and orbits (symmetry or asymmetry); ciliary borders; puncta lachrymalia; upper and lower cul-de-sacs; conjunctivæ; caruncles; corneæ (oblique illumination and loupe); irides (mobility and color); anterior chambers (depth and character of contents); vision; accommodation; balance external eye muscles; adduction, abduction, sursumduction; position of eyes; mobility of globe;

<sup>1</sup> This order of examination is modified from the one employed by Dr. Weir Mitchell in the Infirmary for Nervous Diseases.



## 56 Examination and Functional Testing

tension ; light-sense ; color-sense ; fields of vision ; field of fixation ; ophthalmoscope ; ophthalmometer ; retinoscope : test-lenses.

This schedule of examination must be modified to suit individual cases, as these present trivial local lesions directly discoverable by inspection, or forms of disease requiring detailed study for their proper interpretation.

**Direct Inspection of the Eye.**—After the preliminary examination which the case demands, the surgeon proceeds to the direct inspection of the eye. The surfaces of the lids should be examined for swollen superficial veins, a common

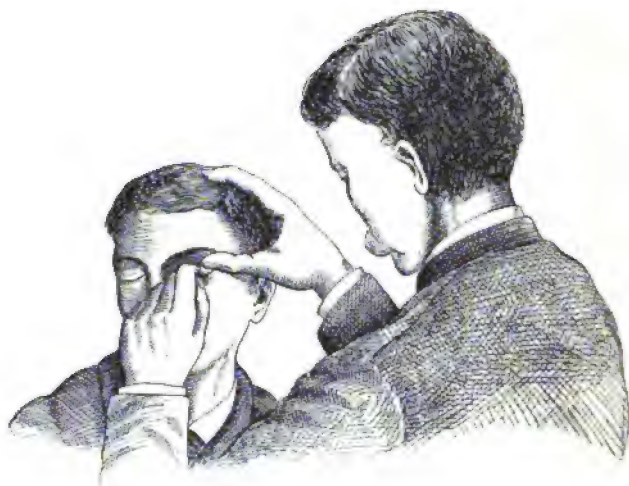


FIG. 26.—Position of hands in the act of everting the eyelid.

index of inflammation of the globe ; their edges for inflammation, parasites, and misplaced cilia ; the puncta for permeability, pressure at the same time being made over the lacrimal sac in order to express from it through the puncta any contained fluid ; the upper and the lower conjunctival cul-de-sac for accumulated secretion, granulations, and foreign bodies ; the palpebral conjunctiva for hardened secretion in glands ; the caruncles for swelling, attached foreign bodies, and irritation by incurved cilia ; and the conjunctiva for the information to be derived from its blood-vessels.

In order to evert the lid, observe the following rules: Require the patient to turn the eye strongly downward, seize gently the central eyelashes of the upper lid between the index-finger and thumb of the left hand, draw the lid downward and away from the ball, place the point of the thumb of the right hand above the tarsal cartilage of the lid which is to be everted, the remaining fingers being steadied on the brow, and, by a quick movement, turn the edge of the lid over the point of the thumb, while this is simultaneously depressed.



FIG. 27.—Eyelid everted for examination of its under surface and the upper part of globe.

During the entire manœuver insist upon the downward direction of the patient's eyes; otherwise the lid cannot be turned without undue force and pain. When there are no lashes on the upper ciliary margin, the lower lid should be pushed beneath the edge of the upper in such a manner that it acts as a wedge on which the superior lid is then everted.

The surgeon should inspect the skin of the face and forehead, examine the orbits by palpation, ascertain the action of the orbicularis by causing the patient to close his eyes as if

in sleep, and study the length, width, and symmetry of the palpebral fissures and the condition of the commissural angles.

**Blood-vessels of the Conjunctiva.**—In health only a few conspicuous blood-vessels are to be observed; in inflammation many more become visible. The arteries of the conjunctiva are derived from the palpebral and lacrimal branches of the ophthalmic; those of the episcleral tissue arise from the anterior ciliary branches of the ophthalmic, while the border of the cornea is surrounded by a plexus of capillary loops derived from the anterior ciliary vessels. This blood-supply may be conveniently divided, as Mr. Nettleship has done, into three systems:

*System I.*—Posterior conjunctival vessels, whose congestion produces a bright red, velvety color, moving, on pressure of the eyelids, with the shifting of the conjunctiva, usually associated with mucopurulent secretion, and indicating conjunctivitis. Conjunctival congestion is most intense at the fornix and in its neighborhood, and decreases as the corneal margin is approached.

*System II.*—Anterior ciliary vessels, composed of perforating and non-perforating arteries and veins. The perforating arteries, which supply the sclerotic, iris, and ciliary bodies, are the branches seen in health entering about 5 mm. from the corneal margin, their points of entrance, in dark-complexioned people, often being distinctly tinted.

The non-perforating (episcleral) branches, invisible in the normal eye, produce, when congested, a pink zone surrounding the cornea ("ciliary congestion," "circumcorneal zone"), not moving on pressure of the lids with the shifting of the conjunctiva, unassociated with purulent discharge, and one indication of iritis. Ciliary congestion is most distinct around the corneal margin and lessens as the fornix is approached. As Haab remarks, the most congested circumcorneal zone is least involved in pure conjunctival congestion.

The perforating veins and their non-perforating (episcleral) twigs, when congested, create a zone of dusky hue, often a symptom of glaucoma, or appear in unequal, deep-seated

patches of lilac or violaceous color, pointing to cyclitis or scleritis.

**System III.**—Anterior conjunctival vessels and the plexus of capillaries surrounding the cornea, derived from anterior ciliary vessels through whose numerous small branches anastomosis between System I. and II. takes place. Their congestion produces a circle of bright-red injection, often partly on the cornea, a sign of inflammation of this membrane, and typified in the early vascular stages of interstitial keratitis (see page 309).

In addition to these three varieties of congestion, numerous departures are noticeable, making it impossible to separate the form and specify the individual system involved. In these types is found a definite local injection, as the leash of vessels passing to a corneal ulcer; or all the systems are commingled in a general inflammation.

**Temperature of the Conjunctival Sac.**—According to Silex, the temperature of the lower human conjunctival fold is  $35.55^{\circ}\text{C}$ . ( $95.99^{\circ}\text{F}$ .)—*i. e.*, about  $2^{\circ}\text{C}$ . lower than that of the rectum. There is an average increase of  $0.98^{\circ}\text{C}$ . in inflamed eyes, the highest temperature being found in acute iritis.

**Inspection of the cornea** reveals inflammation, vascularization, ulceration, opacities, and foreign bodies. Slight irregularities are detected by placing the patient before a window, while the eyes are made to follow the uplifted finger held about one foot from the face, and moved in various directions. The image of the window-bars reflected from the cornea will be broken as it crosses the spot of inequality.

A more accurate method is to employ a *keratoscope* (Placido's disc). This instrument consists of a disc shaped like a target, upon which are drawn concentric black circles, a sight-hole being in the center. The patient is placed with his back to the window, while the surgeon holds the instrument in front of the eye, and, looking through the central aperture, observes the reflections of the circles from the cornea. If these are broken or distorted, the indications of irregularity in the surface are present.

Minute abrasions and ulcers, if suspected, and yet not determined, may be found by dropping on the eye a concentrated alkaline solution of *fluorescin* (Gruebler's fluorescin, 2 per cent.; carbonate of soda, 3.5 per cent.), which colors green that portion of the cornea deprived of its epithelium, while the healthy epithelium remains unaffected. When the lesion is not very recent, or when it is covered with necrotic tissue, the coloration will be yellowish or yellowish-green. This substance also stains the endothelium of the cornea (see page 371). Toluidin-blue, as suggested by Veasey, and eosin may likewise be used as coloring agents.

**The Width of the Cornea.**—This may be measured approximately by holding before it a rule marked in millimeters, and noting the number of spaces its width occupies, or with Priestley Smith's *keratometer*, which consists of a scale situated between two planoconvex lenses. The average horizontal diameter of the normal cornea is 11.6 mm. (Priestley Smith).

**The Sensibility of the Cornea.**—This may be tested by gently touching the surface of this membrane with a wisp of cotton twisted to a fine point. If sensation is normal, the touch should be instantly followed by the reflex act of winking. The opposite eye should always be tested as a control.

**Oblique illumination** is a method of examination by which the cornea, the anterior chamber, the iris, and, if the pupil is dilated, the lens and even the anterior layers of the vitreous, may be studied. The surgeon places the patient two feet from the source of illumination, and focuses a beam of light with a two-inch or three-inch lens upon the cornea, at the same time observing the surface under examination through a lens of the same focal distance, held between the thumb and forefinger, the disengaged fingers being utilized to elevate the upper lid (Fig. 28).

The distance of the lens must be varied slightly, according as the cornea, iris, or crystalline lens is brought within its focus, the patient being required to look up, down, and to either side, while all the anterior surfaces and media of the eye are illuminated. In order to detect foreign bodies in the

cornea, the light should be directed at an acute angle. If the posterior pole of the lens is to be examined, the light is thrown perpendicularly into the pupil, the surgeon placing his eye in the same direction without interfering with the light.

By this method minute abrasions, previously undetected foreign bodies, channels of old vessels, and other corneal changes may be examined. The character of the aqueous humor, the depth of the anterior chamber, the surface of the iris, the presence of synechia, small tumors, atrophic fibers, and persisting pupillary membrane are evident, and, finally,

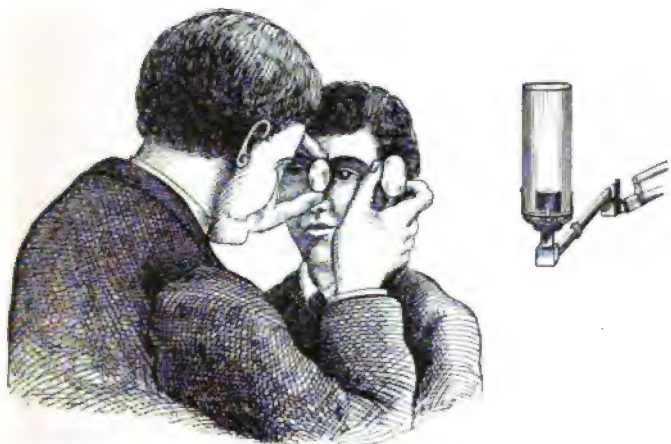


FIG. 28.—Method of oblique illumination.

opacities in the anterior capsule and axis of the lens are discoverable.

The routine examination by means of lateral illumination, provided the eye is unaffected with an inflammation associated with so much photophobia that this is not possible, will often afford information unattainable by other methods.

**The Corneal Loupe.**—This is a lens, properly mounted, by which the cornea is strongly magnified, and which should be employed with oblique illumination. A "corneal microscope" or a specially prepared lens of high power permits the study of minute changes in this membrane, and is utilized for the examination of the traces of former vascularization, particu-

larly after interstitial keratitis (see page 310), and by its help even the circulation of the blood in the vessels of a pannus may be studied.

Recently Dr. Edward Jackson has designed a *binocular magnifying lens* which possesses material advantages.

**The Color of the Iris.**—The color of the irides varies: blue and gray are the predominating hues in northern countries; brown occurs next in frequency; while the various admixtures produce yellow and green shades. Black irides are never seen; but dark irides, taking into account the whole population of the world, are of the most frequent occurrence. The color of the iris of all new-born children is of a light grayish-blue; the stromal pigment is developed subsequently.<sup>1</sup>

Slight differences in shade between the two irides are not uncommon; more rarely, even in health, the irides differ in color (chromatic asymmetry), one being brown or greenish, the other blue or gray. Almost invariably, in cases of this sort, one iris corresponds in color with the irides of one parent, and the remaining iris with those of the other parent. Instead of uniform pigmentation, a single triangular patch, or several irregular spots of dark color, may appear upon one or both irides (piebald irides). This condition is sometimes temporary. Chromatic asymmetry, while perfectly compatible with health, has been observed in patients with neuropathic tendencies—chorea and epilepsy (Féré); in other instances there is liability to disease on the part of the lighter eye (cataract). This phenomenon may be present in several members of the same family.

Discoloration from disease results in one iris being green, that of the fellow being blue, and indicates iritis or cyclitis; it is often an early symptom of inflammation of the iris, and should be looked for in every inflamed eye. When the dark segments seen in a piebald iris are small, they have been mistaken by incautious observers for foreign bodies.

**The Pupil.**—The size of the pupil in health varies with exposure to light and with accommodation and convergence.

<sup>1</sup> Ely records two dark irides in more than 1000 newly born children; one child was a negro.

There is no physiologic standard on which to base a measurement. The pupil is generally smaller in old age, in blue irides, and in eyes with hyperopic refraction; it is larger in youth, in dark irides, and in eyes with myopic refraction. With the accommodation at rest, the diameter of the pupil varies from 2.44 to 5.82 mm., the average diameter being 4.14 mm. (Woinow). The position of the pupil is a little to the nasal side of the center of the cornea, and, under similar illumination, the pupils should be round and of equal size, although slight inequality of the pupils is sometimes seen in healthy persons.

It is much to be regretted that the recorded variations in the diameter of the pupil are commonly imperfect, and that the loose statements, "pupils dilated," "pupils contracted," "pupils medium-sized," have crept into many reports.

**Measurement of the Pupil.**—The pupil can be measured approximately by holding before it a rule, marked in millimeters, and noting the number of spaces its width occupies. The chief objection to this method is that the distance subtended on the rule is less than the diameter of the pupil, in proportion as the distance from the observer's eye is less to the rule than to the pupil (Jackson).

A great variety of instruments, known as *pupillometers*, have been devised for the accurate measurement of the width of the pupil. A very simple and serviceable device is Randall's modification of Follin's instrument, which consists of a scale of circles held close to the observed eye, the scale being slowly rotated until that circle which matches the pupil in size is reached. Priestley Smith's *keratometer* (page 60) may be used for the same purpose.

All examinations should be made under a uniformly strong light, and the character of light should be stated.

**Mobility of the Iris.**—**Pupil-reflexes.**—The reflex mobility of the iris is tested to find the presence of attachments between the iris and the lens (*synechiæ*), or atrophy of the iris, or to ascertain the sensitiveness to light of the retina or visual center.

Variations in the size of the pupil depend upon variations



## 64 Examination and Functional Testing

in the contractility of the iris. These pupillary movements are often called *pupil-reactions* or *pupil-reflexes*. They are as follows:

1. *The direct light-reflex of the pupil*—that is, the contraction of the pupil obtained by illuminating the pupillary area. It is tested as follows: The patient is placed before a window in diffuse daylight, and one eye is carefully excluded. He is directed to look into the distance with the exposed eye, which is then shaded, and, if it is normal, a considerable dilatation of the pupil will occur. On removing the covering hand or card, contraction to the same size as that which existed before the test was applied takes place.

2. *The consensual light-reflex, or indirect reflex action of the pupil*—that is, the contraction of the pupil of one eye, which

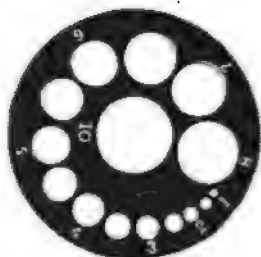


FIG. 29.—Simple pupillometer.

is evident when the pupillary area of the opposite eye is illuminated. In other words, the pupil of one eye acts in unison with its fellow, and in normal eyes the pupils should be equal not only with both eyes open, but with one eye shaded.

3. *The accommodation- and convergence-reflex*, called also the *associated action of the pupil*—that is, the contraction of the pupil which takes place when the visual axes converge upon a near point. The patient is required to look into the distance and then quickly direct his eyes at a near object,—for example, the point of a pencil held at a distance of about 10 cm.,—when a contraction of the pupil will occur under the influence of accommodation and convergence—that is, the sphincter of the iris contracts in association with the ciliary muscle and the internal recti. The extent of this action is less than in the

two preceding ones and is more closely connected with convergence than with accommodation.

4. *The sensory reflex of the pupil*, sometimes called the *skin-reflex*, or the *pain-reaction*—that is, a slight dilatation of the pupil which occurs on stimulating sensory nerves. It may be tested by pinching the skin of the neck, or, better, by applying to it a faradic brush.

5. *The reaction of the pupil to drugs*—that is, the mydriasis which occurs under the influence of the mydriatic drugs and the myosis which takes place under the influence of the myotic drugs (see page 140).

When a pupil has been contracted under the influence of light, convergence, or accommodation, and the stimulus is withdrawn, the pupil will return to the size it had before the stimulus was applied, if the conditions remain the same. This return or relaxation has been called by Walter Jessop *the dilatation- or relaxation-reflex of the pupil*.

The pupillary movements depend partly upon the muscular tissue within the iris and its nerves, and partly upon the vascular supply. The muscular tissue is divided into the *sphincter pupillæ*, a well-marked circular band of involuntary muscle surrounding the inner margin of the iris, and certain radially placed fibers, much less clearly marked, and the existence of which is sometimes disputed, called *the dilatator pupillæ*.

The nerves which supply the pupillary muscles are the *myotic* and the *mydriatic* nerves.

The *myotic tract* begins in the nucleus of the third nerve, reaches the lenticular ganglion by its short root, and finally arrives at the sphincter of the pupil by means of the short ciliary nerves. Stimulation of this tract produces contraction of the pupil; section of it, moderate dilatation of the pupil.

The *mydriatic tract*, according to Walter Jessop, proceeds from a center in the medulla along the spinal cord as far as the second dorsal nerve. It then follows the communicating branch of this nerve to the cervical sympathetic, and reaches the plexus around the internal carotid artery. From this point it passes to the nasociliary branches of the nasal nerve, which, as the long ciliary nerves, supply the muscular tissue

## 66 Examination and Functional Testing

of the iris with mydriatic fibers. Stimulation of this tract produces wide dilatation of the pupil; section of it, moderate contraction of the pupil.

The contraction of the pupil which occurs when the eye is exposed to a source of light in the manner described is a reflex. The *afferent pathway* is the optic nerve, the chiasm, the optic tract of the same side, and perhaps also of the opposite side, until it reaches the nucleus of the third nerve, where the *efferent* or myotic tract already described begins. It is probable that communicating fibers between the corpora quadrigemina and center for the third nerve, called Meynert's fibers, enable the reflex to take place. The consensual light-reflex occurs because the stimulus passes to the opposite eye either by reason of the decussation of the fibers in the chiasm, or because of its transference from one nucleus to the other. The accommodation-convergence reflex occurs because the stimulus passes along the previously described afferent pathway to a center in the aqueduct of Sylvius, and from there through the third nerve to the iris. The centers for accommodation, convergence, and pupil-contraction are in close proximity.

**Dilatation of the pupil** occurs in glaucoma, in cases of non-conductivity of light (atrophy), in orbital disease, and under the influence of mydriatics. It is further seen in fright, emotion, anemia, in depressed nervous tone, aortic insufficiency, cutaneous stimulation (*skin-reflex*), and irritation of the cervical sympathetic.

In diseases of the nervous system, dilatation of the pupil, when of cerebral origin, indicates extensive lesion; when of spinal origin, irritation of the part (McEwen). Systematic writers have divided dilatation into *irritation mydriasis*, caused by irritation of the pupil-dilating center or fibers, and *paralytic mydriasis* (iridoplegia), caused by paralysis of the pupil-contracting center or fibers.

**Contraction of the pupil** (*myosis*) appears in congestions of the iris, in certain fevers, in plethora, venous obstruction, mitral disease, pulmonary congestion, paralysis of the sympathetic, and under the influence of myotics.

If the myosis is of cerebral origin, it indicates an early irrita-

tive stage of the affection (meningitis, etc.); if of spinal origin, a depression, paralysis, or even destruction of the part (McEwen).

Systematic writers divide contraction of the pupil into *irritation* and *paralytic myosis*. The same factors which cause myosis may cause mydriasis, the determining factor being the degree and the duration of the lesion.

Small pupils are connected with degeneration of the posterior columns of the cord (*spinal myosis*). Pupils unaffected by the changes of light and shade, but contracting under the influence of convergence of the visual axes, known as Argyll-Robertson pupils (*reflex iridoplegia*), are frequent in tabes. The lesion is in the fibers which pass from the proximal end of the optic nerve to the oculomotor nuclei, or is nuclear. *Unilateral reflex iridoplegia* may be due to lesion in the sphincter nucleus, and is seen in tabes dorsalis and syphilis. The reverse of the Argyll-Robertson symptom has been observed, and indicates disease in a special part of the oculomotor nucleus.

**Unequal pupils** (*anisocoria*) are rarely seen in health. If there is recent wide dilatation of one pupil and no disease of the eye, the instillation of a mydriatic may be suspected. Unequal pupils occur in eyes with widely dissimilar refraction, if one eye is blind, in aneurysm, dental disease, traumatism, and in diseases of the nervous system. If the disease is cerebral, the inequality denotes unilateral or focal brain disease. Anisocoria is not uncommon in tabes, disseminated sclerosis, and parietic dementia. *Varying inequality* of the pupils (*springing mydriasis*) or a one-sided mydriasis, now occurring on the one side and now on the other, is a serious premonitory symptom of insanity.

**Special Pupillary Phenomena.**—The *hemioptic pupillary inaction* is referred to on page 561. The *cerebral cortex reflex of the pupil* (Haab's reflex) consists of a marked bilateral contraction, which takes place if the patient sits in a darkened room and directs, without change of accommodation or convergence, his attention to a bright object already present within the compass of the field of vision. The *orbicularis*

*pupillary reaction* (Gifford-Galassi reflex, often called the Westphal-Piltz reaction), is a contraction of the pupil which occurs when a forcible effort is made to close the lids. This excites in the nucleus of the orbicularis fibers of the facial an activity which is transferred to the pupil-contracting center, or it may be due to a mechanical effect produced by the strong contraction of the orbicularis. Dilatation of the pupil under the influence of light stimulus and contraction when it has been shaded have been described in cases of meningitis as *paradoxical pupillary reactions*.

*Hippus* is a rhythmic contraction and dilatation of the pupil occurring without alteration of illumination or fixation. It is a normal phenomenon, but occurs in exaggerated degree in hysteria, mania, meningitis, and other diseases of the nervous mechanism.

**Testing Acuteness of Vision.**—The acuity of vision is the power of distinguishing form and size, and is a function of the macula lutea, the peripheral portions of the retina having only indifferent ability to distinguish form and size.

In order to determine the acuity of sight, test-types are employed, in which the letters are of various sizes, and constructed according to the methods described on page 40.

When it is desired to test the acuity of vision, the patient is placed 6 meters from the type-card, in a well-lighted room, and each eye is tried separately. If the letters of No. 6 (20 feet approximately) are read, vision is normal, or 1, but if, at the same distance, no smaller letters than those numbered 18 (60 feet) can be discerned, vision is  $\frac{1}{3}$ . It is usual to express

these results according to the formula  $V = \frac{d}{D}$ , in which  $V$  stands for visual acuteness,  $d$  for the distance of the patient from the card, and  $D$  for the distance at which the type should be read; so that in these instances the vision would be recorded  $\frac{6}{6}$  and  $\frac{6}{18}$ , or in feet,  $\frac{20}{xx}$  and  $\frac{20}{lx}$ . The rays coming from the letters at 6 meters' distance have so little divergence when they reach the eye that they are usually considered parallel. Hence if the patient sees distinctly at this distance,

his vision is perfect at the longest range (see also page 45). In point of fact, however, there is an appreciable divergence of the rays from the distance mentioned, equivalent to one-sixth of a diopter, and in the final adjustment of glasses this divergence should be recognized. Any other distance may be chosen, provided it does not place the patient closer to the test-card than 3 meters, at which close range the function of accommodation would introduce an element of inaccuracy. Thus, the scale made use of by de Wecker, and elaborated by Oliver, assumes  $\frac{5}{5} \left( \frac{15}{xv} \text{ approximately} \right)$  instead of  $\frac{6}{6}$ , as  $\frac{1}{1}$ . In like manner, a 4-meter distance may be utilized, as has been done by Edward Jackson.

The acuity of sight, as tested with types constructed on the basis of an angle of  $5'$ , does not always yield accurately the highest vision attainable; indeed, many good eyes possess a vision of  $\frac{4}{5}$  of the standard angle. For this reason Dr. James Wallace has arranged a series of test-types in which an angle of  $4'$  has been substituted as the basis of each letter.

For the purpose of a control test, and also for determining visual acuity of illiterate persons, cards are employed on which a number of differently arranged dots are placed, of sizes which should be counted at different distances, and among these Burchardt's international tests are the most useful. For the same purpose incomplete squares corresponding in size to the test-letters have been constructed, the incomplete sides being turned successively in different directions. Wolffberg has designed a useful test which consists of small pictures of well-known objects, which in size approximately conform to the standard angle.

If the patient fails to decipher the largest letters at the distance employed, he should be moved closer to the card; thus, he may be unable to read the type numbered 60 at 6 meters, but may discern this at 4 meters,  $V = \frac{4}{60}$  or  $\frac{1}{15}$  of normal. Still further depreciation of visual acuity is recorded by requiring the subject to count the outstretched fingers at various distances, 2, 3, or 6 feet,  $V =$  counting fingers at 2

feet. For determining the lower degrees of sharpness of vision by a method more precise than the one just described, Landolt's *optotypes* may be employed.<sup>1</sup> When the ability to distinguish form (*qualitative light perception*) no longer exists, the perception of light should be tried by alternately screening and shading the eye, or by illuminating the eye with light reflected from a mirror.

**Light-sense.**—Having determined the acuity of vision by means of the test-letters, the examiner has ascertained the *form-sense*, and may proceed to try a second subdivision of the sense of sight, the *light-sense*, which is the power possessed by the retina, or center of vision, of appreciating variations in the intensity of the source of illumination.

An instrument called a *photometer* is employed for this purpose, and consists essentially of an apparatus—for example, the one designed by Izard and Chibret—by which the intensity of two sources of light may be compared. The patient, looking into the instrument, sees two equally bright discs. One disc is now made darker, and the power of the eye to perceive the difference in the illumination of the two discs ascertained; or one disc is made entirely dark, and then gradually illuminated, and the smallest degree of light noted by which the patient can perceive the disc coming from the darkness. The former is called the *light-difference* (L. D.), and the latter the *light-minimum* (L. M.). By means of Förster's photometer the lowest limit of illumination with which an object is still visible (the *minimum stimulus*) is ascertained. The light-sense may also be tested with gray letters on a white ground. For determining the "light minimum" R. Wallace Henry's photometer is very useful. Some information in regard to the light-sense may be obtained by testing the acuity of vision on two cards, under a different degree of illumination, and by comparing the results with a similar examination of a subject believed to have normal power of appreciating different degrees of illumination. De Wecker's *photometric types* may also be employed. These consist of

<sup>1</sup> *Ophthalmic Record*, 1899, vol. viii., p. 624.

white letters placed upon gray backgrounds of different intensities.

**Color-sense.**—A third subdivision of the sense of sight is the *color-sense*, or the power which the retina has of perceiving color, or that sensation which results from the impression of light-waves having a certain refrangibility. This examination is of especial interest in the detection of *color-blindness* (see page 540).

**1. Method of Holmgren.**—This consists in testing the power of a person to match various colors, conveniently used in the form of colored yarns. The set of worsteds contains 3 large test-skeins, namely: (1) *light pure green*, (2) *rose-purple*, (3) *red*; and 150 small skeins of the following colors: red, orange, yellow, yellow-green, pure green, blue-green, blue, violet, purple, pink, brown, and gray. In addition there are several shades of each color, and a number of gradations of each tint, from the deepest to the lightest. According to Holmgren, the method of examination should be as follows:

“The wools are placed in a heap on a large table, covered by a light cloth and in broad daylight. A skein of the test-color is taken from the pile and laid far enough away from the others not to be confounded with them during the examination. The person examined is required to select other skeins from the pile nearly resembling it in color, and to place them by the side of the sample. He is made thoroughly to understand that he is required to search the heap for the skeins which make an impression on his chromatic sense, and quite independently of any name he may give the color similar to that made by the test-skein. The examiner should explain that resemblance in every respect is not necessary; that there are no two specimens exactly alike; that the only question is the resemblance of the color, and that, consequently, the candidate must endeavor to find something similar in shade, something lighter and darker of the same color, etc.

“**TEST I.**—The green test-skein is presented. The examination must continue until the candidate has placed near the test-skein all the other skeins of the same color; or else, with these or separately, one or more of the skeins of the class of



confusion colors, or until he has sufficiently proved, by his manner, that he can easily and unerringly distinguish the confusion colors, or gives unmistakable proof of a difficulty in accomplishing it. The candidate who places with the test-skein confusion colors (gray, drab, fawn, light pink or yellow)—that is to say, finds that they resemble the test-color—is *color-blind*; while if he evinces a manifest disposition to do so, though he does not absolutely do so, he has a *feeble chromatic sense*.

“TEST II.—The rose-purple skein is presented. The examination must continue until the candidate has placed all or the greater part of the skeins of the same shade near the sample; or else, simultaneously or separately, one or more skeins of the confusion colors. If he confuses the colors, he will select either the light or deep shades of blue and violet, especially the deep, or the light and deep shades of one kind of green, or gray inclining to blue. A candidate who is proven color-blind by the first test, and who in the second test selects only purple skeins, is *incompletely color-blind*. If in the second test he selects with the purple blue or violet, or one of them, he is *completely red-blind*. If in the second test he selects with purple only green or gray, or one of them, he is *completely green-blind*. The red-blind never select the colors taken by the green-blind, and *vice versa*. The green-blind will often place a violet or blue skein by the side of the green, but it will then only be the brightest of these colors.

“TEST III.—The red skein is presented. The test, which is applied to those completely color-blind, should be continued until the person examined has placed beside the test-skein all the skeins belonging to this hue, or the greater part, or else one or more confusion colors. The red-blind chooses besides the red, green and shades of brown, which, to the normal sense, seem darker than red. On the other hand, the green-blind selects shades of these colors which appear lighter than red.

“The absence of all except one color sensation (*monochromatic vision*) will be recognized by confusion of every hue having the same intensity of light. *Violet-blindness* will be

recognized by a genuine confusion of purple, red, and orange in the second test."

**2. Method of Thomson.**—Dr. William Thomson has devised the following arrangement of the yarns: The set consists of a large green and a large rose test-skein, and 40 small skeins, each marked with a bangle having a concealed number, extending from 1 to 40, placed in a double box, so arranged as to keep the two series apart.

The large green skein being placed near by, the small skeins from 1 to 20 are placed in good daylight, and the employé under examination is directed to select 10 shades of the same color as the test-skein. One with normal vision will choose promptly the 10 greens with odd numbers.

A color-blind person will hesitate, and his selections will contain some even numbers, and the confusion colors will be shades of brown, etc., containing some red, or shades of gray, and will indicate the color defect. These figures are to be recorded on a blank, and the 20 skeins are to be removed. The large rose skein is then used, and the examination repeated in like manner with skeins numbered from 21 to 40, and the result recorded. The confusion skeins, which have even numbers, are blue, green, and gray. From the selections made by the man found color defective by the green test we are able to decide the character of his color-blindness. Those selecting blues are red-blind, those taking greens and grays are green-blind, according to the nomenclature of Holmgren. There are 10 roses and 10 confusion colors in the second series.

**3. The Lantern Test.**—To control and also to substitute the various wool-tests, lanterns for detecting color-blindness are employed. Useful models have been designed by William Thomson, Charles H. Williams, and Edridge-Green. Concerning lantern tests, Dr. Thomson writes as follows: "Whilst the wool-tests have been accepted universally as requisite for the detection of color defects, the employés of railroads and their friends have always objected to their use as having no relation to their daily duties, and have demanded such colors as are employed as signals. Furthermore, for two-fifths of the time during the night of an employé's life he is expected

## 74 Examination and Functional Testing

to govern his actions by colored lights, and hence a lantern which can imitate the night signals in form, color, intensity, and size, as they appear under all obstructions caused by rain, snow, fog, and smoke, is desirable. Its power over the wools to detect the central amblyopias of tobacco, alcohol, drugs, and disease, that would not be revealed by the skeins, makes it a necessity."

Dr. Thomson describes his lantern as follows: "It consists of an asbestos chimney, which can be placed on the kerosene lamp in universal use on railroads, or over an Argand or other gas light, electric lamp, or spring candle-stick. Two discs, four inches in diameter, are so placed upon the chimney as to permit of their being superimposed partly. The lower disc contains seven glasses in apertures  $\frac{1}{2}$  inch in diameter, having the white, red, green, and blue colors in general use on railroads. This may be considered the 'examination in chief,' whilst the upper disc, when combined with the lower by turning one or both, furnishes the 'cross-examination.' The upper disc has two apertures, one  $\frac{1}{2}$  of an inch, the other  $\frac{1}{4}$  inch with white glass. The other five have one white ground glass, one deep London smoke, one pink, one green, and one cobalt-blue glass.

"The combination of the white ground and the smoke glass with the reds and greens of the lower disc enables all atmospheric conditions to be imitated, and the lights to be diminished in brightness and tint. The use of the small opening enables size and distance of signals to be imitated.

"The standard for color-sense is taken as an opening of  $\frac{1}{12}$  inch at 20 feet. A man failing to see the colored light at this distance may have it increased ten times =  $\frac{2}{3}$  by using the large openings. Again failing, he may approach to one foot and reveal a color-sense equal to  $\frac{1}{10}$  only. The resemblance to the tests for form by Snellen's letter is to be noted. Since the color-blind depend alone on intensity of brightness to distinguish the white, green, and red signals, the diminishing effect of the ground glass and of the London smoke often reveals the defect. The cobalt, transmitting blue and red both, is usually described by the color-blind as blue, which color they always see well, being blind for red. The cobalt, combined with the lower reds, gives a very deep red color, which, when compared with the usual red, may induce the color-blind to name one red, the other green. Combined with the lower blue it gives a deep pink, called blue by the color-blind.

"In the pink, London smoke, and light green glasses in the upper disc I have imitated the 'confusion colors.' The pink looks cherry red to the normal eye, but it transmits both red and blue by the spectroscope, hence the color-blind pronounce it blue, or, when backed by a yellow flame, white. The light green is also called white, as is also the light gray of the London smoke. Hence we

have in these three glasses tints which the color-blind name white, and reveal their defect thereby.

"The upper disc has its seven openings marked by the letters of the alphabet, and the lower by the numerals from one to seven. The examination should be made in a darkened room, and the results reported on a blank, the details being used when requisite. The man examined is expected to call or name the colors and to recognize them when being seen at 1 minute at 20 feet."

#### 4. The Pseudo-isochromatic Plates of Stilling.—

These consist of a series of plates (10 in number), each plate containing 4 squares filled by small, irregular, colored spots, among which other spots in a confusion color, made to conform to an Arabic figure, are placed. The test-plate is held in a good light, and the examiner requires the subject to distinguish the tracings. These plates are said to be of practical use.

**5. Special Tests.**—These include the use of the *spectroscope* and various forms of *chromatometers*, the chromatophotometer of Chibret being the instrument that is perhaps most valuable.

*Direct vision for colors* may be studied by placing the patient at a given distance from a chart or disc of graduated colors, and noting the amount of surface exposure which is required for the color to be properly recognized.

**Accommodation** has been defined to be those changes in the optical adjustment of the eye effected by the ciliary muscle, and in practice is measured by finding the nearest point at which fine print can be clearly deciphered. The type usually adopted is that known as Snellen's 0.5 or Jäger's 1.

In order to study the phenomena of accommodation the student should record: (1) The nearest point of perfectly distinct vision attainable with the smallest readable type, or the *punctum proximum* (abbreviated *p. p.*, or simply *p.*). (2) The farthest point of distinct vision, or *punctum remotum* (abbreviated *p. r.*, or simply *r.*). (3) The *range, amplitude* of accommodation, or the expression of the amount of accommodative effort of which the eye is capable. This is expressed in the number of that convex lens, placed close to the cornea, whose focal length equals the distance from the near point to the cornea, and which gives rays a direction as if they had

come from the far point; thus, if the near point be 7 cm., the lens which expresses the amplitude of accommodation is  $+14\text{ D } \frac{100}{7} = 14$ . (4) *Relative accommodation*, or that in-

dependent portion of this function which can be exercised without alteration in a given amount of convergence, and which is divided into a *negative* portion, or that portion which is already in use, and a *positive* portion, or that portion which is not in use (see also pages 41 and 53).

**Mobility of the Eyes.**—This is tested by causing the patient to follow, with his eyes, the head remaining stationary, the movements of the uplified finger, which is directed to the right, to the left, upward and downward. Both eyes must be observed, and note made of any lagging in their movements, or of the failure of either eye readily to turn into the nasal or temporal canthus. At the same time the relation of the movements of the upper lid to those of the eyeball is recorded. The attention of the patient must be centered upon the moving finger, and allowance should be made for the imperfect mobility of highly myopic eyes. Any asymmetry of the skull or difference in the level of the two orbital margins may be observed, because such conditions are not infrequently associated with ametropic eyes, especially when the two eyes possess great inequality in refractive conditions.

**Balance of the External Eye Muscles.**—Under normal conditions perfect equilibrium of the external eye muscles is present, and there is no interference with binocular fixation and binocular single vision (see page 568). Under abnormal conditions the movements of the eyes may be deranged so that one eye deviates, or tends to deviate, from the point of fixation—that is, from the object which it is regarding. These deviations may be classified thus:

1. *Manifest deviation*—that is, a deviation of an eye which the patient cannot overcome. This is known as *strabismus*, *squint*, or *heterotropia*, and is fully considered on pages 570 and 573

2. *Latent deviation*—that is, a tendency of the visual line to deviate from the point of fixation. This tendency, however,

is overcome by a muscular effort, owing to the stimulus which the eyes always have to maintain binocular single vision. It is generally described by the term *latent squint*, *suppressed squint*, or *heterophoria*. It is frequently designated *insufficiency of the ocular muscles*, and was called by von Graefe *dynamic strabismus* (see page 607).

According to G. T. Stevens,<sup>1</sup> the various conditions of equilibrium or variation from it may be arranged in four classes :

1. *Orthophoria*, a tending of the visual lines in parallelism.
2. *Heterophoria*, a tending of the visual lines in some other direction, but with ability to adjust them habitually for single vision.
3. *Heterotropia*, a deviation of the visual lines from parallelism in such manner that they cannot habitually be united at the same point of fixation.
4. *Anotropia*, *katotropia*; or *anophoria*, *katophoria*—variations from equilibrium which may or may not be consistent with parallelism of the visual lines, but in which, with the least innervation of the eye muscles, the visual lines of both eyes would fall below (*katotropia*) or rise above (*anotropia*) the most favorable plane for the minimum effort. Thus with *ano-* or *katotropia* there may be associated *heterophoria* or *heterotropia*.

*Heterophoria* may be divided into the following specific conditions :

1. *Esophoria*, a tending of the visual lines inward.
2. *Exophoria*, a tending of the visual lines outward.
3. *Hyperphoria* (right or left), a tending of the visual line of one eye (right or left) in a direction above its fellow, constituting, as the case may be, right or left hyperphoria.

The term does not imply that the line to which it is referred is too high, but that it tends higher than the other, without indicating which may be at fault.

The compound tendencies are :

1. *Hyperesophoria* (right or left), a tendency of one visual line above the other, with a tendency also of the lines inward.
2. *Hyperexophoria* (right or left), a tendency for one visual line to rise above the other, with a tendency also outward.

*Heterotropia* may be divided into two subclasses :

(a) Deviations consistent with a physiologic state of the muscles and nerves, as in the ordinary concomitant squint.

(b) Deviations resulting from pathologic conditions—as, for example, deviations from paralysis or from mechanical causes.

The specific divisions of the subclass (a) are :

1. *Esotropia*, a deviation of the visual lines inward.
2. *Exotropia*, a deviation of the visual lines outward.

<sup>1</sup> *A System of Diseases of the Eye*, edited by Norris and Oliver, vol. ii., p. 171.

## 78 Examination and Functional Testing

3. *Hypertropia* (right or left), a deviation of one visual line above the other.

4. *Hyperesotropia* and *hyperexotropia* are the compound deviations.

*Cyclophoria* is a term introduced by Savage to describe want of equilibrium of the oblique muscles.

In order to ascertain the condition of the ocular muscles the following tests are employed :

1. **The Screen (Cover) and Parallax Tests.**—Require the patient to regard a small point of light upon a black background 5 or 6 meters distant, or a round black spot 1 inch in diameter in the center of a white card-board at a similar distance. Cover the left eye with a screen, making sure that the patient is fixing the test-object with his right eye. Pass the screen rapidly from the left to the right, and observe the movements of the eye which take place behind the cover. Outward deviation indicates exophoria, inward deviation esophoria, vertical deviation hyperphoria. The prism, placed base inward, which neutralizes the outward deviation is a measure of the exophoria; the prism, placed base outward, which neutralizes the inward deviation, is a measure of the esophoria; the prism, placed base up or base down, which neutralizes the vertical deviation, is a measure of the hyperphoria.

While the screen is being moved rapidly from one eye to the other request the patient to describe the apparent movement of the test-object. If this moves in the same direction in which the cover is moved, exophoria is indicated; if in the opposite direction, esophoria; if upward or downward, hyperphoria. These apparent movements may be neutralized as before with appropriately placed prisms.

Require the patient to fix upon a fine object, as a pencil-point, held below the horizontal, 20 or 25 cm. from the eye, and, in order to remove the control of binocular vision, cover one eye with a card or the hand, and observe whether the eye under cover deviates inward or outward, upward or downward, and returns to fixation when the cover is removed, and neutralize the movement with appropriately placed prisms.

2. **Prism Tests.**—A small flame is placed against a dark

background at 5 or 6 meters from the patient, and on a level with his eyes. In an accurately adjusted trial-frame a prism of  $7^\circ$  is inserted, base down, before one eye—for example, the right. Vertical diplopia is induced, and the upper image belongs to the right eye. If the flames stand one directly over the other, there is no inclination to divergence or convergence. If the upper image stands to the left, there is exophoria; if to the right, esophoria. That prism placed with its base in or out before the left eye, according to circumstances, which brings the two images into a vertical line, measures the degree of the deviation.

In order to test the functions of the vertical muscles at a distance of 6 meters the patient is seated as before, and a prism of sufficient strength to induce homonymous diplopia is placed before one eye,—for example, the right,—*i. e.*, with its base toward the nose. If the images are on the same level, no deviating tendency is present. If, for example, the right image rises higher than the other, the visual line of the right eye tends to be lower than that of its fellow, and there is hyperphoria. That prism, placed with its base down before the left eye, which restores the images to the horizontal level, measures the degree of deviation.

**3. Equilibrium Test.**—In order to test the functions of the lateral muscles at the ordinary working distance, or 30 cm., it is customary to employ the equilibrium test of von Graefe, in which a card, having upon it a large dot, through which a fine line is drawn, is held 25 or 30 cm. from the eyes, diplopia being induced by means of a prism of  $10^\circ$ , base up or down, before one eye. A more accurate test-object is a small dot and fine line, or a single word printed in fine type, requiring accurate fixation and a sustained effort of accommodation. If, the prism being placed base down before the right eye, the images stand exactly one above the other, equilibrium is evident; if the upper image (image of the right eye) stands to the left of the lower image, there is *crossed lateral deviation*; and that prism, placed before the left eye with its base toward the nose, which restores the images to a vertical line, measures the tendency to divergence or exophoria. If the upper image



stands to the right of the lower, there is *homonymous lateral deviation*; and that prism, placed before the left eye with its base toward the temple, which restores the images to a vertical line, measures the tendency to convergence or esophoria. The vertical muscles should also be tested at the ordinary working distance with a prism placed before one eye, with the base before the nose, as already described above.

4. In order to test the **convergence near point**, approach a finger or pencil to the nearest point upon which the eyes can converge. This should be situated at no greater distance than 8 cm. ( $3\frac{1}{4}$  inches) from the eyes—that is, 2.5 to 4.5 cm. ( $1-1\frac{3}{4}$  inches) from the nose. If, before this point is reached, outward deviation of one eye occurs, the amount of convergence is deficient.

5. In order to ascertain the power of **adduction** (properly *prism-convergence*), **abduction** (properly *prism-divergence*), and **sursumduction** (*sursumvergence*), the strongest prism which the lateral and vertical muscles can overcome is found (see page 569).<sup>1</sup>

Beginning with *adduction* (*prism-convergence*), find the strongest prism placed before one eye, with its base toward the temple, through which the flame still remains single. The test should begin with a weak prism, the strength of which is gradually increased until the limit is ascertained. This varies from  $30^{\circ}$  to  $60^{\circ}$ , the higher degrees, however, in most instances being attained only after a reasonable degree of practice.

In like manner *abduction* (*prism-divergence*) is tested, the prism now being turned with its base toward the nose;  $6^{\circ}$  to  $8^{\circ}$  of prism should be overcome. The ratio between adduction and abduction should be 6 to 1 (Stevens)—*i. e.*, if adduction is  $48^{\circ}$ , abduction should be  $8^{\circ}$ ; but, according to Risley,

<sup>1</sup> According to Duane, the term "adduction" is properly applied only to the amount ( $40^{\circ}$ – $50^{\circ}$ ) by which each eye can turn inward when moving parallel with its fellow (*associated adduction*, or adduction proper); "abduction" to the absolute degree of rotation of each eye outward in performing associated parallel movements, which is  $40^{\circ}$ – $50^{\circ}$ ; "sursumduction," to the absolute degree of movement of either eye upward—a movement of some  $40^{\circ}$  in extent.

in carefully corrected or emmetropic eyes, the ratio is 3 to 1. Banister found the primary adduction for 6 meters to be only  $14^{\circ}$ . As Hansell and Reber properly observe, no arbitrary standard of the ratio between prism-convergence and prism-divergence can be given, although the latter is fairly constant under normal conditions.

*Sursumduction* (*sursumvergence*), or the power of uniting the image of the candle-flame, seen through a prism placed with its base downward before one eye, with the image of the same object as seen by the other eye, is ascertained by beginning the trial with a weak prism,  $\frac{1}{2}^{\circ}$  or  $1^{\circ}$ , and gradually increasing its strength. The limit is usually  $2^{\circ}$ , but may be as high as  $6^{\circ}$  or  $8^{\circ}$ . *Right sursumvergence* is equivalent to



FIG. 30.—Risley's rotary prism.

the degree of that prism placed base down before the right eye (or base up before the left), and *left sursumvergence* to the degree of that prism placed base down before the left eye (base up before the right) through which the test-object still remains single. Right and left sursumvergence are normally equal.

If the eyes of the patient under examination are ametropic, the proper correcting lenses should be placed before them, and the examination for the various forms of heterophoria made through this glass, which should be accurately centered.

Practically, all the examinations for muscular errors can be made with a series of prisms and a trial-frame, but they are facilitated by the use of certain instruments of precision, especially some form of Herschel or *revolving prism*, the one devised

## 82 Examination and Functional Testing

by Risley being the best. The latter consists of two prisms, superimposed with their bases in opposite directions, constituting a total value of  $45^\circ$ . They are mounted in a cell which has a delicately milled edge, and fits in the ordinary trial-frame. The milled edge permits convenient turning in the frame, so that the base or apex of the prisms can be readily placed in any desired direction. The prisms are caused to rotate in opposite directions by means of a milled screw-head, projecting from the front of the cell. With this rotary prism the strength of the abducting, adducting, and supra- and infra-

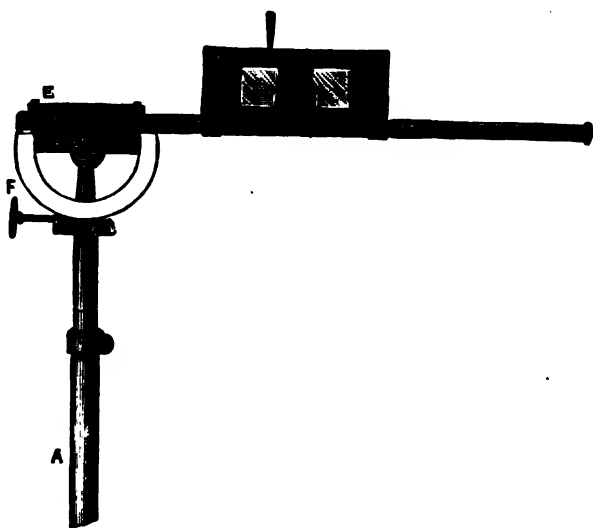


FIG. 31.—Stevens's phorometer.

ducting muscles can be measured. If the rotary prism is placed before the left eye with the zero mark vertical and the screw turned to the right or left, it will cause the base of the resulting prisms to be either inward or outward—that is, toward the nose or temple, as may be desired; or it may be placed with the zero mark horizontal, and the base turned upward or downward. All examinations for muscular defects may be ascertained with Dr. G. T. Stevens's *phorometer*.

**6. Obtuse-angled Prism Test.**—One of the simplest tests of the ocular muscles is the *obtuse-angled prism* of Maddox.

This is composed of "two weak prisms of  $3^{\circ}$  united by their bases. On looking through the line thus formed at a distant flame, two false images of it are seen, one higher and one lower than the real image seen by the other eye, the position of which, to the right or the left of the line between the false images, indicates the equilibrium of the eye. A faint band of light, of the same breadth as the two false images, is seen extended between them" (Fig. 32). The answers of the patient may be materially assisted by placing a red glass before one eye, and thus tinting the real image. If this stands directly in the center between the two false images, all forms of latent deviation are eliminated; if it stands to the right or to the left, there is exophoria or esophoria; if it stands above or below the center, or is fused with either the upper or the lower image, there is hyperphoria.

**7. Insufficiency of the oblique muscles (*cyclophoria*),** according to Savage, may be detected "by placing a Maddox prism, with its axis vertical, before one eye, the other being covered, which regards a horizontal line on a card 18 inches distant. This line appears to be two, each parallel with the other. The other eye is now uncovered, and a third line is seen between the other two, with which it should be parallel. Want of harmony in the oblique muscles is shown by want of parallelism of the middle with the other two lines, the right end of the middle line pointing toward the bottom and the left end toward the top line, or *vice versâ*, depending upon the nature of the case" (Fig. 33).

**8. Cobalt Test.**—A trial-frame armed on one side—for example, the right—with a piece of *cobalt glass* is placed in posi-

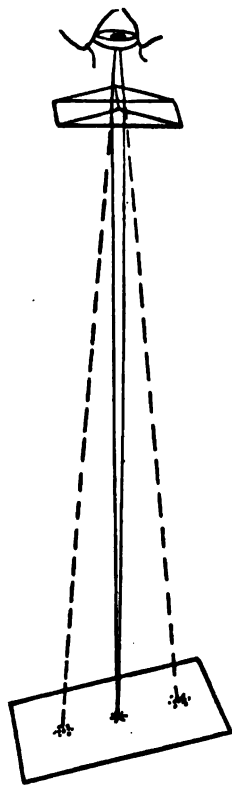


FIG. 32.—Position of the images as seen through the obtuse-angled prism of Maddox.

## 84 Examination and Functional Testing

tion and the patient required to regard the test-light. The right image will be smaller than the left, and have a blue center and a red border if the patient is hyperopic or emmetropic, and a red center with a blue border if the patient is myopic. Suitably placed prisms, which unite the images, are the measures of the deviation. This test is commended by Dr. William Thomson.

**9. The Rod Test.**—This test was designed by Maddox, and depends upon the property of transparent cylinders to cause

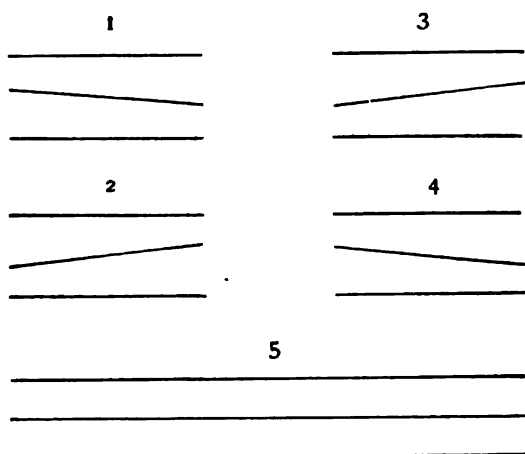


FIG. 33.—Tests for insufficiency of oblique muscles: 1, Insufficiency of left superior oblique; 2, insufficiency of left inferior oblique; 3, insufficiency of right superior oblique; 4, insufficiency of right inferior oblique; 5, equilibrium of oblique muscles (Savage).

apparent elongation of an object viewed through them, so that a point of light becomes a line of light so dissimilar from the test-light that the images are not united. It may be suitably employed by having mounted in a cell, which will fit in the trial-frame, a transparent glass rod colored red,  $\frac{3}{4}$  of an inch long, and about the thickness of the ordinary stirring rod used by chemists, or a series of glass rods placed one above the other (Fig. 34).

The examination for *horizontal deviation* is thus described: "Seat the patient at 6 meters from a small flame, placed against a dark background, and place the rod horizontally



FIG. 34.—Maddox multiple rod.

before one eye. If the line passes through the flame, there is orthophoria (equipoise), as far as the horizontal movements

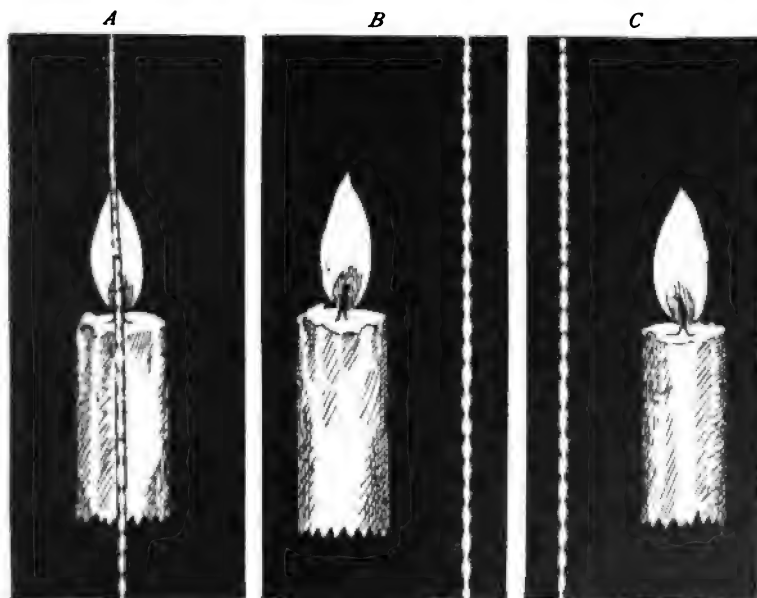


FIG. 35.—Maddox's rod test for horizontal deviation. The rod is before the right eye. *A*, The line passes through the flame—orthophoria. *B*, The line passes to the right of the flame—latent convergence, or esophoria. *C*, The line passes to the left of the flame—latent divergence, or exophoria.

of the eyes are concerned. Should the line lie to either side of the flame, as in most people it will, there is either latent convergence or latent divergence; the former, if the line is on

## 86 Examination and Functional Testing

the same side as the rod (homonymous diplopia); the latter, if on the other side (crossed diplopia)."

In order to test the *vertical deviation*, the rod is placed vertically before the eye; a horizontal line of light appears, and the patient is asked if the line passes directly through the flame or if it appears above or below it. The following rule, quoted from Maddox, will suffice to indicate the "hyperphoric" eye: "If the flame is lowest, there is a tendency to upward deviation of the naked eye; if the line is lowest, of the eye before which the rod is placed."<sup>1</sup>

The measurement of the extent of the deviation may be

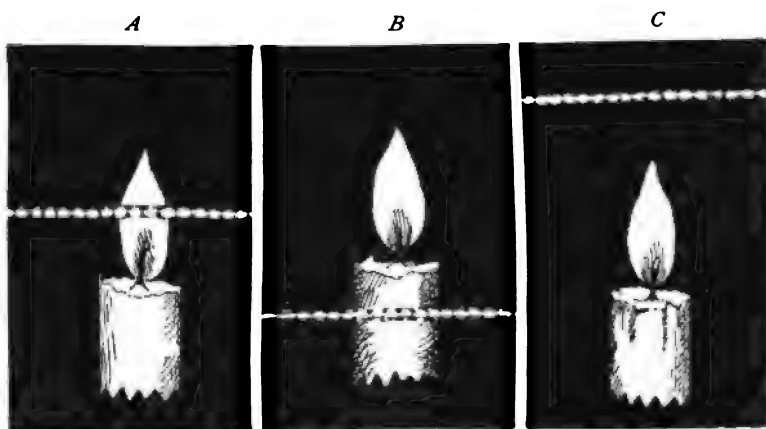


FIG. 36.—Maddox's rod test for vertical deviation. The rod is before the right eye. *A*, The line passes through the flame—orthophoria. *B*, The line passes below the flame. The upper image belongs to the left eye—right hyperphoria. *C*, The line passes above the flame. The upper image belongs to the right eye—left hyperphoria.

made in the ordinary way, by finding that prism, placed before the naked eye (preferably with the rotary prism of Risley), which brings the line and flame together.

Of the various tests described, the Maddox rod is simple, and for all practical purposes accurate, especially when it is employed to estimate vertical deviations. According to Duane,

<sup>1</sup> Dr. Swan M. Burnett substitutes for the Maddox rod a 6 D cylinder.

it is apt to indicate an excess of deviation, particularly in esophoria. Hansell and Reber doubt if the prism-test reveals the true state of the muscle balance. They have found distinct contradictions between its results and those of the Maddox rod and other tests, and this is a matter of common experience. It is probable that the screen and parallax tests, if carefully and repeatedly performed, give, as Duane believes, most trustworthy information.

**Power of Convergence.**—In order to determine the maximum of convergence, an instrument known as an *ophthalmodynamometer* may be employed. The best one has been devised by Landolt,<sup>1</sup> and consists of a metallic cylinder, blackened on the outside, placed over a candle-flame. The cylinder contains a vertical slit, 0.3 mm. wide, covered by ground glass. The luminous vertical line thus produced is the object of fixation. Beneath the cylinder is attached a tape-measure graduated on one side in centimeters, and on the other in the corresponding number of meter angles. The fixation object is gradually approached in the median line toward the patient, until that point where double vision occurs is reached, or the nearest point (*punctum proximum*) of convergence, and the distance in centimeters read from one side of the tape, and the corresponding maximum of convergence in meter angles on the other.

The minimum of convergence may also be ascertained with the instrument, but when this is *negative* it is determined by finding the strongest abducting prism—that is, base in before one eye—which will not cause diplopia while the patient is fixing a candle-flame at 6 meters. If the number of the prism is divided by 7, the quotient will approximately give in meter angles the amount of deviation of each eye when the prism is placed before one. The amplitude of convergence is equivalent to the difference between the maximum and minimum of convergence—that is,  $a = p - r$ . Thus, if the normal average of maximum convergence is 9.5 meter angles and the average minimum of convergence is -1 meter angle, the amplitude

<sup>1</sup> Landolt's *Refraction and Accommodation of the Eye*, page 283.



## 88 Examination and Functional Testing

of convergence would be  $a = 9.5 - (-1) = 10.5$  meter angles (see Meter Angles, page 51).

**The Field of Vision.**—When the visual axis of one eye is directed to a stationary point, not only is the object thus “fixed” visible, but also all other objects contained within a given space, which is large or small, in proportion to the distance of the fixation point from the eye. This space is the *field of vision*, and the objects within it imprint their images upon the peripheral portions of the retina, or those which are independent of the macula lutea. In contradistinction to visual acuity and refraction, which pertain to the macula in the act of *direct vision*, the function of sight capable of being performed by the rest of the retina is called *indirect vision*.

The limits of the visual field may be roughly ascertained in the following manner: Place the patient with his back to the source of light, and have him fix the eye under examination, the other being covered, upon the center of the face of the observer or upon the eye of the observer which is directly opposite his own, at a distance of two feet. Then let the surgeon move his fingers in various directions midway between himself and the patient, on a plane with his own face, until the limits of indirect vision are determined, controlling at the same time the extent and direction of the movements by his own field of vision. This method suffices to discover any considerable limitation, and, in the event of such discovery, should be supplemented by a more exact procedure.<sup>1</sup>

If it is desired to have a map of the field not larger than  $45^\circ$  in extent, let the patient be placed 25 cm. from a black-board, which may be conveniently ruled in squares, and fix the eye under observation upon a small white mark. The observer then moves the test-object—a piece of white paper 1 cm. square, affixed to a black handle—from the periphery toward fixation, until the object is seen. If eight peripheral points are marked and afterward joined by a line,

<sup>1</sup> In the systematic examination of the eye it is not usual to map out the field of vision before an ophthalmoscopic examination has been made; but the description of the methods is conveniently placed here.

a fair map of the field of vision will be obtained,<sup>1</sup> which may be transcribed upon a chart, like the one originally suggested by Joy Jeffries (Fig. 37). In like manner the *campimeter* of de Wecker may be employed.

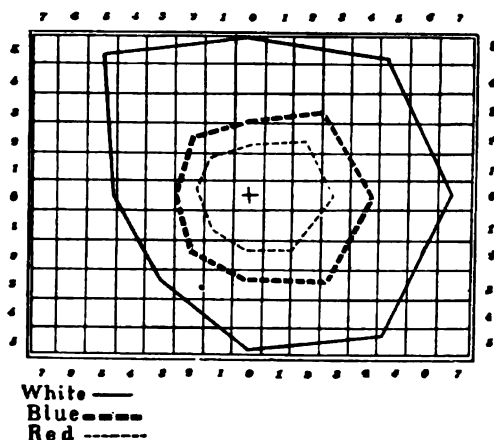


FIG. 37.—Limits of the normal field for white, blue, and red, transcribed upon a blackboard (after Norris).

Beyond  $45^\circ$  this method ceases to be accurate, because on a flat surface the object is too far away from the eye; rays perpendicular to the visual line coming from a peripheral object would be parallel to the blackboard, and could not arise from it, or any object passed across its surface.

<sup>1</sup> The value in degrees of the squares on the blackboard may be ascertained by the following table, provided the eye is placed exactly at 25 cm. from the fixation point :

2.2 cm.	=	$5^\circ$	in the perimeter semicircle.
4.4 "	=	$10^\circ$	" " "
6.7 "	=	$15^\circ$	" " "
9.1 "	=	$20^\circ$	" " "
11.7 "	=	$25^\circ$	" " "
14.4 "	=	$30^\circ$	" " "
17.5 "	=	$35^\circ$	" " "
21 "	=	$40^\circ$	" " "
25 "	=	$45^\circ$	" " "
30 "	=	$50^\circ$	" " "
36.7 "	=	$55^\circ$	" " "
43.3 "	=	$60^\circ$	" " "

Hence, the investigation of the periphery of the retina requires the use of an instrument known as a *perimeter*. This

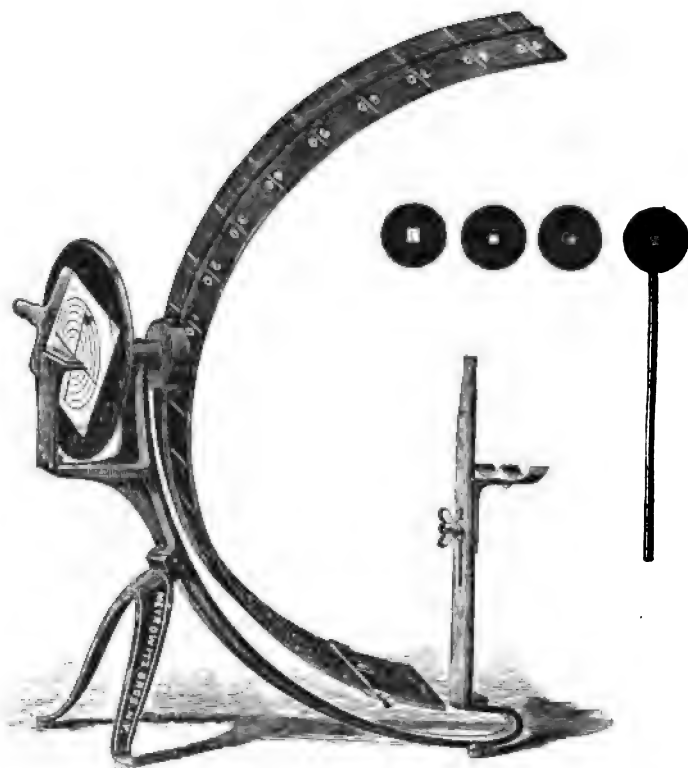


FIG. 38.—Perimeter. The examination may be made with the carrier which moves along the semicircle, or the test-objects may be carried along this by means of dark discs attached to a long handle, each disc containing in its center the test-object. The patient's chin is placed in the curved chin-rest; the notched end of the upright bar is brought in contact with the face, directly beneath the eye to be examined, which attentively fixes the center of the semicircle. The other eye should be covered, preferably with a neatly adjusted bandage. The record chart is inserted at the back of the instrument, and, by means of an ivory vernier, the examiner is enabled to mark exactly with a pencil the point on the chart corresponding to the position on the semicircle, at which the patient sees the test-object. The various marks are then joined by a continuous line, and a map of the field is obtained (see Fig. 39).

consists essentially of an arc marked in degrees, which rotates around a central pivot, that at the same time may be the

fixing-point of the patient's eye, which is placed 30 cm. distant (the center of curvature of the perimeter arc), or the eye may be directed upon a porcelain button on a bar, placed  $15^{\circ}$  from the center, to the left, if the right eye is to be examined; *vice versa*, if the left is under observation. The test-object, 1 to 2 centimeters in diameter, affixed upon a carrier, is moved from without inward, and the point noted on each meridian where it is recognized. The result is transcribed upon a chart, prepared by having ruled upon it radial lines to correspond to the various positions of the arc, and concentric circles to note the degrees.

Many ingenious instruments have been devised, especially such as are self-registering, among which may be mentioned those of McHardy, Stevens, Skeel, and Priestley Smith. The hand perimeter of Schweigger for bedside examinations is useful.

The physiologic limits of the form field, or, what is practically the same thing, the field when this has been mapped with a square of white  $1\frac{1}{2}$  cm. in width, are: outward,  $90^{\circ}$ ; outward and upward,  $70^{\circ}$ ; upward,  $50^{\circ}$ ; upward and inward,  $55^{\circ}$ ; inward,  $60^{\circ}$ ; inward and downward,  $55^{\circ}$ ; downward,  $72^{\circ}$ ; downward and outward,  $85^{\circ}$ .<sup>1</sup>

<sup>1</sup> These limits, which form a good working field, are somewhat exceeded by the mean limits resulting from the examination of a number of normal eyes, as recorded by Foerster, Landolt, and Baas. The last-named author finds the average result of ten observers as follows: Outward,  $99^{\circ}$ ; upward,  $65^{\circ}$ ; inward,  $63^{\circ}$ ; downward,  $76^{\circ}$ . Figures indicating a *minimal field*, or *smallest physiologic field*, have been recorded, varying from  $90^{\circ}$  (Foerster) to  $50^{\circ}$  (Treitel) outward;  $55^{\circ}$  to  $21^{\circ}$  upward;  $60^{\circ}$  to  $40^{\circ}$  inward;  $70^{\circ}$  to  $40^{\circ}$  downward. The smaller of these limits cannot be regarded as physiologic, and the greater is about equal to the average working field.

Bjerrum proposes an addition to the usual method of examining the field of vision, a description of which is condensed from Berry's translation of the original paper. The addition consists in making use of white objects which subtend a very small visual angle. The examinations are made at a distance of 2 meters, using a large black screen 2 meters in breadth, which can be let down from the ceiling to the floor. At this distance the blind spot (see page 96), instead of measuring 2.5 cm., as on an ordinary perimeter, measures 20 cm. in diameter; and everything else is in the same proportion.

The objects used by Bjerrum are small circular discs of ivory, fixed on the end of a long, dull black rod. They vary from 10 to 1 mm. in diameter. The ex-

## 92 Examination and Functional Testing

These measurements, which represent the *relative visual field*, vary within normal limits, and, transcribed upon a chart, produce the following figure (Fig. 39).

From this it is evident that the field of vision is not circular, being greatest in extent outward and below, and most restricted inward and above. This restriction is partly due to the presence of the edge of the orbit and the nose, and partly, as Landolt has pointed out, because the outer part of the retina is less used than the inner, and its functions, therefore, are less developed. Hence, as each portion of the field

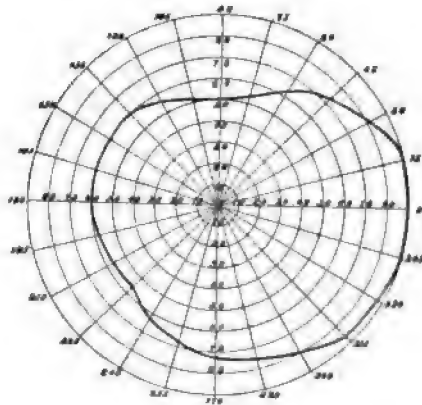


FIG. 39.—Diagram of the field of vision for white (1 cm. square test-object), transcribed upon a perimeter chart.

corresponds to the opposite portion of the retina, the inner part is smaller than the outer. To avoid the influence of the physical obstacles afforded by the cranial bones, the eye should be made to fix an object in each meridian  $30^\circ$  in the direction opposite to that under measurement.

**Binocular Field of Vision.**—The field of vision for each eye examination is begun in the ordinary manner (at 30 cm.), with the 10 mm. disc, and then continued at 2 meters' distance with a 3 mm. disc. In the first case, the visual angle approximately is  $2^\circ$ , in the second,  $5'$ . The normal boundaries in the first instance have been given; in the second they are  $35^\circ$  outward;  $30^\circ$  inward;  $28^\circ$  downward; and  $25^\circ$  upward. Small concentric limitations are unimportant, but the method is valuable in finding sector-shaped defects, irregular limitations, and scotomata (page 96).

having been defined, it remains to point out that the field of vision which pertains to the two eyes, or that portion in which binocular vision is possible, constitutes only the area where the central and inner parts overlap. This is evident from the diagram. The continuous line *L* bounds the field of vision of the left eye, and the dotted line *R* the visual field of the right eye. The central white area corresponds to the portion common to both eyes, or to that area in which all objects are seen at the same time with both eyes; the shaded areas correspond to the portions in which binocular vision is wanting. In the middle of the white area lies the fixation point *f*, and on each side of it the blind spots of the right and left eye, *r* and *l*.

Having thus determined the *limits* and *continuity* of the

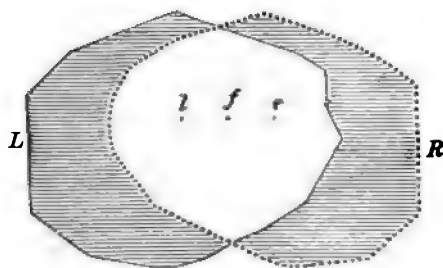


FIG. 40.—Binocular field of vision (Möser).

visual field, the functions of the peripheral parts of the retina in regard to perception of colors, acuity of vision, and appreciation of light should be investigated.

The *color-field* is mapped in the manner described in connection with the general visual field, the squares of white in the carrier of the instrument being replaced by pieces of colored paper 1 cm. in diameter.

The order in which the colors are recognized from without inward is: (1) Blue; (2) yellow; (3) orange; (4) red; (5) green; (6) violet. In practical work, blue, red, and green are the colors employed, red and green being the color-sense most usually affected in pathologic cases. Non-saturated colors are not correctly recognized when the test-object is first seen.

## 94 Examination and Functional Testing

Thus, yellow at first appears white; orange, yellow; red, brown; green, white, gray, or gray-blue; and violet, blue. The physiologic limits of the color-fields, which, like those of the general field, are subject to variations, when estimated with 1 cm. square test-object correspond closely to the following:

	Blue.	Red.	Green
Outward . . . . .	80	65	50
Outward and upward . . . . .	60	45	40
Upward . . . . .	40	33	27
Upward and inward . . . . .	45	30	25
Inward . . . . .	45	30	25
Inward and downward . . . . .	50	35	27
Downward . . . . .	58	45	30
Downward and outward . . . . .	75	55	45

These, when transcribed upon a chart, are represented in Fig. 41.

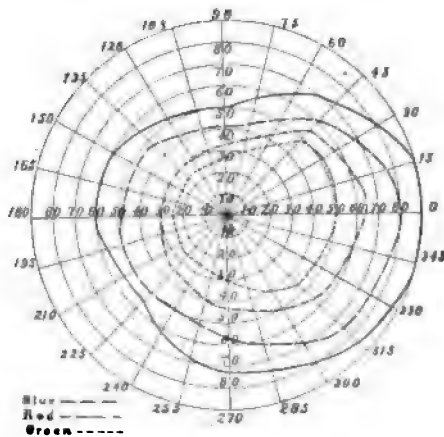


FIG. 41.—Diagram of the field of vision for blue, red, and green. The outer continuous line indicates the limit of the form-field; the broken lines the limits of the color-fields.

The numbers represent the usual limits at which the color is recognized as such. They do not indicate its greatest intensity, which is perceived only at the fixation point. In order to avoid discrepancies, the character of the light, the nature and saturation of the color, and its distance from the eye should be carefully stated in describing examinations.

The *acuity of the vision of the peripheral parts of the retina* may be tested with small squares of black paper (6, 5.3, and 2 mm. black quadrants on a white ground), separated from one another by their own width, by noting the point in each meridian where they are recognized as separate objects; or with gray patches of different intensity on a white ground (Ward Holden).

The *light-sense of the periphery of the retina* may be tested conveniently with Ward Holden's tests. One card has a 1 mm. black point on one side and a 15 mm. quadrant of light gray, having four-fifths of the intensity of white, on the other. With a perimeter of 30 cm. radius the black point and gray patch are each seen by a normal eye outward,  $45^{\circ}$ ; upward,  $30^{\circ}$ ; inward,  $35^{\circ}$ ; downward,  $35^{\circ}$ . The second card has a 3 mm. black point on one side and a darker gray patch, having three-fifths of the intensity of white, on the other. Each is seen on the perimeter arc outward,  $70^{\circ}$ ; upward,  $45^{\circ}$ ; inward,  $55^{\circ}$ ; downward,  $55^{\circ}$ . Card 2 will reveal slight disturbances of light-sense near the periphery and card 1 in the intermediate and central zones.

The *perception of light*, according to the experiments of Landolt, is the most constant function of the healthy retina, and remains nearly the same throughout its surface, while the color- and form-sense rapidly lessen toward the periphery. For practical purposes, a candle-flame passed along the arm of the perimeter may be used as a test-object; and, if vision is very defective, a second candle is made the point of fixation. Progressive diminution of light-sense from center to periphery will be found if test-objects of varying luminous intensity, with the illumination of ordinary daylight, are employed.

The *adaptation of the retina* may be estimated according to Wilbrand's method by investigating the visual field in a dark room with test-object and fixation-point streaked with luminous paint. The examination is made as soon as the patient enters the dark room and again in ten minutes. This interval is sufficient to enable the normal eye to adapt itself so that the extent of the visual field corresponds to that of a white object in diffuse daylight. Delayed adaptation is a phenomenon found in many pathologic conditions.



**Abnormalities of Visual Field and Scotomas.**—The most frequent departures from those limits of the visual field assumed to be normal are general or concentric contraction; contraction limited especially to one or the other side; peripheral defects in the form of reentering angles; absence of one segment or quadrant; and absence of the entire right or left half of the field.

In addition to these defects, search should be made for dark areas within the limits of the visual field, or *scotomas*. These are distinguished as *positive* when they are perceived by the patient in his visual field, and *negative* when within the confines of a portion of the visual field the image of an external object is not perceived, but the affected area is not discovered until the field is examined. Negative scotomas are further divided into *absolute* and *relative*. Within an absolute scotoma all perception of light is wanting, while within the confines of a relative scotoma the perception of light is merely diminished. The latter are *color scotomas*, usually for red and green. Scotomas are further subdivided, according to their situation and form, into *central*, *paracentral*, *ring*, and *peripheral*.

In every normal eye there is a physiologic scotoma, corresponding to the position of the optic nerve entrance, which usually may be found  $15^{\circ}$  to the outer side of, and  $3^{\circ}$  below, the point of fixation; the interval, according to Landolt, being greater in hyperopic than in myopic eyes. This is known as *Mariotte's blind spot*. According to Hansell, the average distance of the center of the blind spot from fixation point is almost identical in emmetropia and hyperopia, but in myopia is about 5 mm. greater.

For the detection of scotomas, small test-objects, white or colored,  $\frac{1}{4}$  of a centimeter square, are employed, which are moved in different directions from the point which the eye under observation attentively fixes, and the spot marked where the object begins to disappear or change its color. The arm of the perimeter is usually marked near the center in half degrees for this purpose. All examinations around the center

of the field of vision, and hence the examination for scotomas, are readily made upon the blackboard.

Berry urges that the ordinary test for scotomas be supplemented by making an examination of the particular area of the field at a distance of 2 meters or more, so as to obtain a larger projection of the blind portion, and to be able to work with smaller retinal images, without necessitating the use of very small objects.

**Tension.**—This term indicates the intra-ocular resistance, and is clinically demonstrable by palpating the globe with the

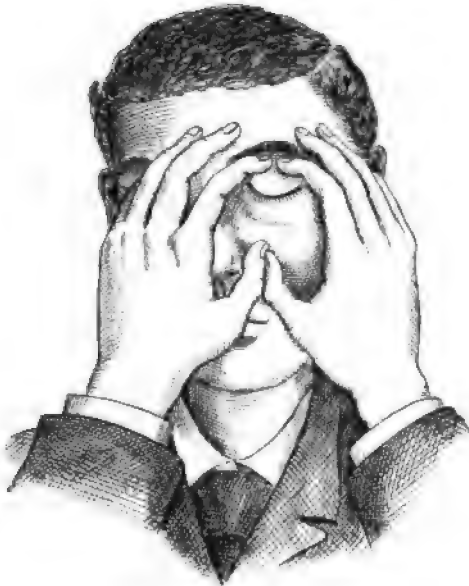


FIG. 42.—Position of hands in determining the tension of an eyeball.

finger-tips. The middle and ring-fingers are placed upon the brow of the patient, the tips of the index-fingers upon the eyeball, and gentle to-and-fro pressure made, the eyes being directed downward. This pressure must be made in such a manner as not to push the ball into the orbit; otherwise no information of its true resistance is obtained. The tension of one eye must always be compared with that of its fellow, and, in any doubtful case, the results may be contrasted with those

## 98 Examination and Functional Testing

obtained by examining an eye known to be normal in another patient of similar age.

Normal tension is expressed by the sign  $T_n$ , and the departures from it by the symbols  $+$ ?,  $+1$ ,  $+2$ ,  $+3$ , and  $-$ ?,  $-1$ ,  $-2$ ,  $-3$ ; the plus signs indicate increased, and the minus signs decreased, resistance. In physiologic experiments, various kinds of apparatus, constructed upon the principle of the manometer, are employed, and for clinical purposes instruments known as *tonometers* have been devised. In practical work, however, sufficiently accurate data are obtainable by a careful use of the educated finger-tips, which, under some conditions, should be placed, as Schweigger advises, directly upon the sclera (see page 402).

**Proptosis**, or protrusion of the eye, may be caused by orbital diseases, tenotomy, paralysis of the ocular muscles, and Graves's disease; while enlargement of the ball is the result of various conditions residing within the globe—myopia, buphthalmos, intra-ocular tumor, and staphyloma. If the cause is unilateral, the resulting condition is asymmetric, and the two eyes may be compared by observing the relative positions of the apices of the corneæ with each other and with the line of the brows.

The eyeball is apparently sunken (*enophthalmos*) in some cases of ptosis and in wasting of the orbital fat, and is diminished in size in high grades of hyperopia and congenital failures of development. As Nettleship has pointed out, the amount of exposed sclera decides the apparent protrusion or recession of the eyeball.

**Position of the Eyes.**—Instead of presenting parallel visual axes, one eye may be deviated inward, outward, downward, or upward, constituting one of the various types of strabismus (see page 570), a condition which may or may not be associated with diplopia (page 575).

### CHAPTER III.

#### REFLECTION. THE OPHTHALMOSCOPE AND ITS THEORY. OPHTHALMOSCOPY AND SKIASCOPY.

**Reflection.**—When light falls upon a polished surface a portion of it is reflected. The angle of reflection is always equal to the angle of incidence. A polished surface, capable of reflecting light, is called a *mirror*. Mirrors are *plane*, *concave*, or *convex*.

A plane mirror reflects the rays falling upon it, so that they seem to come from a point as far back of the mirror as the object lies in front of it. It does not render the rays either convergent or divergent, nor does it lessen their convergence or divergence. Rays parallel before reflection are parallel after reflection. Rays convergent or divergent before reflection maintain the same relation after reflection. In the figure, rays from the object

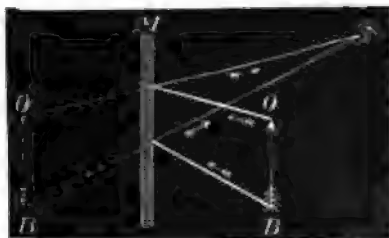


FIG. 43.—Reflection from a plane mirror.

$OB$ , falling upon the mirror  $M$ , are reflected so that they enter the observer's eye, and seem to him to come from  $O'B'$ , situated as far back of the mirror as  $OB$  is in front of it. The image is not inverted. The rays have a divergence from a point whose distance is equal to the sum of the distance from the light to the mirror, and of the distance from the mirror to the eye (compare Skiascopy).

A concave mirror converges parallel rays of light to its principal focus, and forms a real, inverted image in front of the mirror.

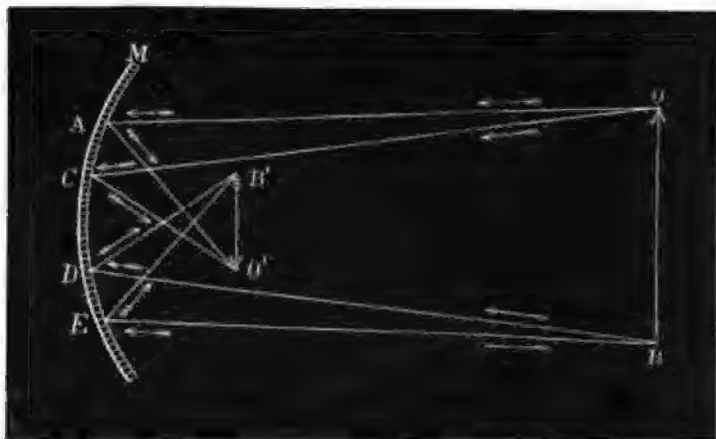


FIG. 44.—Reflection from a concave mirror.

The principal focus of a concave mirror is equal to one-half the length of its radius of curvature,  $F = \frac{r}{2}$ .

The conjugate focal distance for any point greater than the principal focus may be found by the following formula:  $f'$  represents the distance from which the rays diverge (the lamp or candle);  $f''$  is the distance of the conjugate focus.

$$\frac{1}{f'} + \frac{1}{f''} = \frac{1}{F}.$$

$$\frac{1}{f''} = \frac{1}{F} - \frac{1}{f'}.$$

This is understood by recollecting that  $F$  is the focus for parallel rays, and that the focus is the inverse of the reflective or catoptric power of the mirror. The rays which diverge from  $f'$  require  $\frac{1}{f'}$  of catoptric power to render them parallel. This diminishes the catoptric power of the mirror to  $\frac{1}{f''}$ .

$\frac{1}{F} - \frac{1}{f'} = \frac{1}{f''}$ , the focal length of  $f''$  is the conjugate focal distance required.

*Example.*—The ophthalmoscopic mirror has a focus of 20 cm., its radius of curvature being 40 cm. A candle is situated at 30 cm. in front of it, and we wish to know the conjugate focal distance :

$$F = 20 \text{ cm. } f' = 30 \text{ cm. } \frac{1}{20} - \frac{1}{30} = \frac{1}{f''}, \frac{1}{f''} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}, f'' = 60 \text{ cm.}$$

The rays of the candle would be rendered convergent to a point 60 cm. in front of the mirror. The light being placed at a greater distance than the principal focus, the rays are convergent.

A convex mirror renders parallel rays divergent as if they came from its principal focus, which is *negative*, situated behind the mirror, at a distance equal to one-half the radius of curvature. The image is erect and small.

The conjugate focal distances for convex mirrors are obtained by the same formula as for concave mirrors, the sign — being prefixed to  $F$  and  $f''$ .

The cornea, by reflecting light, corresponds to a convex mirror, and in this relation is important in ophthalmometry. The principal focus of the corneal mirror is about 4 mm., the radius of curvature being 7.829 mm. The size of the image reflected from the cornea is proportional to the size of the object as the focus of the corneal mirror, 4 mm., is to the distance of the object. A candle-flame 20 mm. in diameter, situated at 100 mm., gives a corneal image whose size is found in

this manner: Image: 20 :: 4 : 100.  $\frac{\text{Image}}{20} = \frac{4}{100}$ . Image = 0.8 mm. If the radius of curvature is greater, the image is also greater; if the radius of curvature is smaller, the image is smaller. By this means curvature ametropia may be measured.

The size of the corneal image is so very small that it would not be feasible to attempt direct measurement of it. If two candles which are separated some distance are employed as an object, each candle represents one extremity of the object. The size of the object is, then, the distance between the two candles; the size of the image is the distance between the reflected images

of the candles. Suppose this distance to be 3 mm., and by means of a double refracting prism two images of each candle are seen; if they are displaced by the prism exactly 3 mm., so that a straight line passes through all the images, two of them must overlies, as the images are 3 mm. apart. Small variations in curvature will now be manifest if the two images, which should overlies exactly, shoot past each other or fail to come together. The change of form in the crystalline lens during accommodation is proved by this experiment.

#### THE OPHTHALMOSCOPE.

In order to study the interior of the living eye an instrument known as the *ophthalmoscope*, the invention of which, in 1851, we owe to the genius of von Helmholtz, must be employed. The original Helmholtz ophthalmoscope was composed, in general terms, of three thin glass plates, set in a suitable frame at an angle of  $56^\circ$  to the line of sight, by means of which the light was reflected into the observed eye. With this instrument the details of the eye-ground can be studied under a weak illumination.

The modern ophthalmoscope consists essentially of a concave silvered mirror for illuminating the eye, and of lenses for measuring and modifying its refraction ("*refraction-ophthalmoscope*"). The mirror is perforated, as originally suggested by Reute, and swings to either side, so that the obliquely incident rays may be reflected into the eye, without having to tilt the entire instrument, and thus narrow the aperture and render the lenses astigmatic. The lenses are inserted in a disc, invented by Rekow, which can be rotated in front of the sight-hole. A plane mirror, which can be substituted for the concave mirror, is a valuable addition. Many ophthalmoscopes contain two discs, which can be used either singly or in combination. This arrangement affords a series of lenses from 0.50 D to 24 D concave, and from 0.50 D to 23 D convex, with which the observer is enabled to view distinctly the details of the eye-ground in all forms of ametropia. A lens varying from 13 to 20 D accompanies the instrument for focal illumination of the cornea and lens, and for use in

the indirect method of ophthalmoscopy. Among the many ophthalmoscopes at the student's disposal, in the author's opinion none is better than the Loring instrument. Excellent models have been designed by Edward Jackson, B. A. Randall, and A. S. Morton.



FIG. 45.—Loring's ophthalmoscope, with tilting mirror, complete disc of lenses from  $-1$  to  $-8$  and  $0$  to  $+7$ , and supplemental quadrant containing  $\pm 0.5$  and  $\pm 16$  D. This affords 66 glasses or combinations from  $+23$  to  $-24$  D.

**Direct Method.**—The rays from the concave mirror, somewhat converging, enter the pupil and are brought to a focus in the vitreous humor. After reaching their focus the rays diverge again and spread out on the retina into a circle of diffusion. The portion of the retina thus illuminated sends rays back again, which pass through the dioptric media of the eye and are refracted to its far point—that is, if the eye is



emmetropic, they emerge parallel and would meet at an infinite distance; if the eye is myopic, they converge to their far point in front of the eye; if the eye is hyperopic, they diverge from their far point back of the eye (see also page 123).

An observer's eye, in order to focus these rays, must be

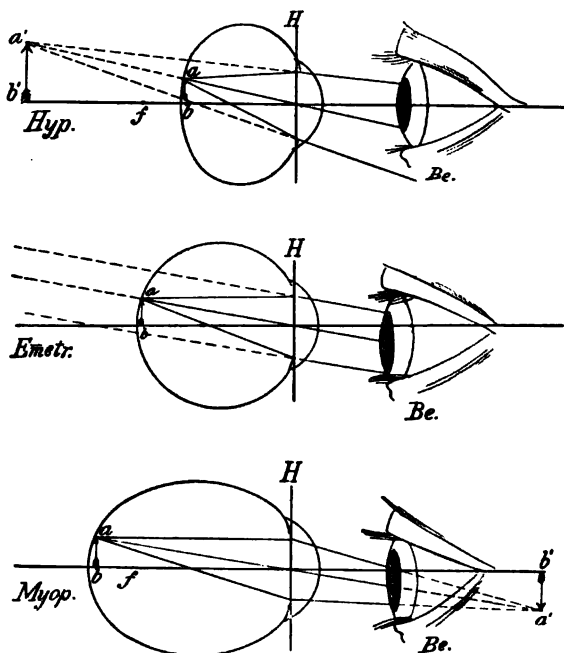


FIG. 46.—Examination in the erect image when the eye examined is hyperopic, emmetropic, or myopic. In each figure three rays are shown emanating from a luminous point on the eye-ground. In hyperopia they diverge after leaving the eye; in emmetropia, they are parallel; in myopia, they converge.  $f$ , The posterior focus;  $H$ , principal plane of the dioptric system of the examined eye;  $Be$ , observer. The ophthalmoscope is not shown (Haab).

adapted to them. If the patient is emmetropic, the observer's eye must also be rendered emmetropic. If the patient is hyperopic, the emmetropic observer must add a convex glass to his eye, or use his accommodation, in order to make the divergent rays parallel. If the patient's eye is myopic, the emmetropic observer must place a concave glass before his eye to render the convergent rays parallel. If the observer

is ametropic, he must first correct his ametropia with suitable lenses (see also page 124). A hyperopic observer might see distinctly the eye of a myopic patient, or a myopic observer might see the eye of a hyperope. In either case the hyperopia must at least be as great as the myopia.

In this method the observer sees the eye just as he would see an object through a convex glass or simple microscope.

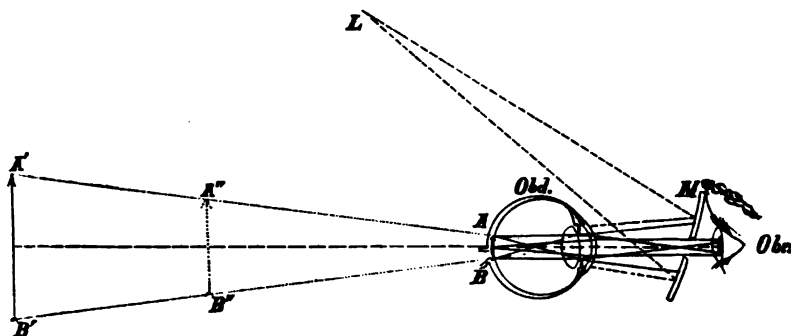


FIG. 47.—Diagram of the direct method with the formation of an upright image: rays from the source of light  $L$  are received upon the concave mirror  $M$ , and converged upon the observed eye  $Obd$ , within which they cross and illuminate an area of its fundus. From an area  $A B$  thus lighted, rays pass out of the pupil (parallel if it be emmetropic, as here represented) through the sight-hole of the mirror, and, entering the observer's eye,  $Obr$ , are focused upon his retina. An image is there formed as though the object seen were at a great distance, and the perceptive centers project it into space as though the object were at some arbitrary distance (e.g., 25 cm.). By the laws of magnification by a simple lens the image is embraced between the lines passing from the optical center of the magnifying lens (the refracting system of the observed eye), through the extremities of the object, and has the size  $A' B'$ ,  $A'' B''$ , etc., according to the distance of projection. In hyperopia rays from  $A$  and  $B$  would be divergent, and the observer would have to render these rays parallel by a convex glass or by using his accommodation. In myopia these rays would be convergent, and a concave glass would be required to neutralize their convergence and render them parallel (B. A. Randall).

The image of the eye-ground is a virtual one—that is, it seems to be behind the eye. It is magnified and erect.

*The formation of the image in the direct method may be understood by examining figure 47.*

Divergent rays and convergent rays have been described, but always in relation to one point. It is now necessary to consider their meaning in reference to an image.

An image is composed of a succession of points ; each one of these points represents a point in the object. From the point in the object one ray passes to the optical center of the lens or lenses, and maintains the same direction after passing through it. This ray is called the *axial ray* ; it passes to the corresponding point in the image. Other rays from the same point in the object diverge from the axial ray at various angles ; a bundle of these rays is called a *pencil*. The size of a pencil is determined by the diameter of a lens or the aperture of the pupil. The lens gives these unequally diverging rays a direction to a common point or focus. From each point in the illuminated part of the retina a pencil of rays falls upon the crystalline lens and cornea. The size of this pencil equals the diameter of the pupil ; to form an image each pencil of rays must be concentrated into one point. By diverging and converging rays is meant the relation the rays from each point bear to each other, not the relation of rays from different points.

**Size of the Image.**—The details of the eye-ground are considerably magnified in the direct method of examination. The optic disc, which measures about 1.5 mm. in diameter, will seem 24 mm. broad, or nearly the size of a twenty-five-cent piece, when projected to 25 cm.

In the emmetropic eye the enlargement is found by the following formula : The distance of the retina from the nodal point (optical center) of the eye is 15 mm. The observer projects the image which he sees to the point at which small objects are usually held, say 250 mm. The enlargement of the disc is proportional to these two distances,  $15 : 250 :: 1.5 \text{ mm.} : 25 \text{ mm.}$   $16.6 =$  the enlargement. It is comparable to looking at the disc through a lens of 15 mm. focus, 66 diopters.

It is to be remembered that the farther this image is projected, the larger it appears. In hyperopia the enlargement is less than this. In myopia, on the contrary, it is greater.<sup>1</sup>

**Indirect Method.**—In the indirect method of ophthalmoscopy a real, inverted image of the interior of the eye is

<sup>1</sup> For a further consideration of this subject, the student may consult Helmholtz, *Physiolog. Optics*, p. 216.

obtained by means of a strong convex lens (object-lens), the principle involved being similar to that of a compound microscope.

The observer holds the object-lens (a convex lens of about 20 diopters) close to the patient's eye, and, placing a convex lens of 5 diopters (eye-piece) behind the ophthalmoscope, throws the light into the pupil and moves his eye nearer to or farther from the patient's eye until he distinctly sees a vessel or a portion of the nerve—that is, a real image of the eye-ground is formed by the object-lens at its focal distance in front of the eye. The observer sees this image, in which all the relations of objects are reversed. His eye is at a distance from the image equal to the focus of the lens in the ophthalmoscope—viz., 20 cm.

The image being inverted, the lower portion of it corresponds to the upper part of the eye-ground, and the right side of the image corresponds to the left side of the eye. If the observer moves upward, the image moves downward; if the observer moves to the right, the image moves to the left. Consequently, the upper part of the image must be viewed if it is desired to see the lower part of the eye-ground, and the right side of the image if parts of the fundus to the left are to be examined.

A comparison between the images as seen by the direct and indirect method may be stated thus: If, in the *direct method* with the disc in view, the observer moves his head to the right, he brings into view a portion of the retina to the left of the disc. The disc now moves out of the field toward the right, and disappears behind the right edge of the pupil. The image, therefore, moves with the observer. If, in the *indirect method* with the image of the disc in view, the observer also moves his head to the right, he sees the image of the same portion of the retina as in the direct method; but this being to the left of the disc, its image occupies a point to the right of that of the disc. The disc thus appears to have moved toward the left. The image, therefore, moves contrary to the movement of the observer's head. Movements in other directions are explained in the same way.

The *formation of the inverted image* in ophthalmoscopy may be understood by examining Fig. 48.

In hyperopia and emmetropia a convex lens is necessary to render the rays convergent. In myopia the rays emerge convergent, and the convex lens may be dispensed with in the higher grades, though it is still an advantage because it increases the area of the fundus visible at one time.

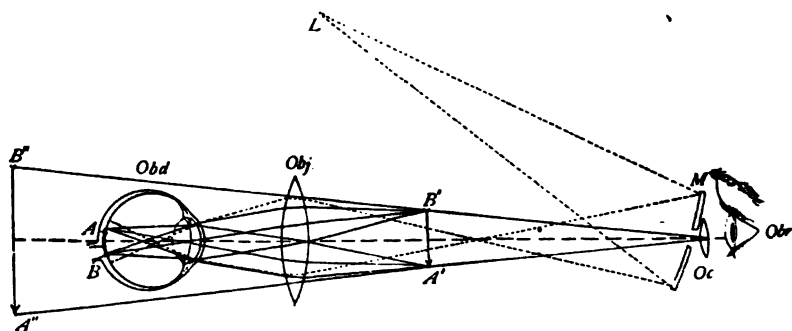


FIG. 48.—Diagram of the indirect method giving an inverted image: rays from the source of light *L*, converged toward the observed eye *Obd* by the concave mirror *M*, are intercepted by the lens *Obj*, and after coming to a focus diverge again and light up the fundus. From a part of the illuminated fundus *AB* rays pass out of the pupil to be again intercepted by the lens *O* and form an inverted real image at its anterior focus *A' B'*. This real image is viewed by the observer's eye behind the sight-hole of the mirror with the aid of a magnifying lens *Oc*, and is seen enlarged, as at *A'' B''* (B. A. Randall).

**Size of the Image.**—The enlargement of the image in this method is less than it is in the direct method, but a larger portion of the eye-ground is visible at one time.

The size of the real image of the eye-ground of an emmetropic eye formed by the convex object-lens held at its own focal length from the eye is determined by the following formula: The size of the disc is to the size of the image as the distance from the retina to the nodal point (15 mm.) is to the focal length of the object-glass. If the lens has a focal length of 75 mm., the ratio is 15 : 75; the enlargement is then 5 diameters. A lens of 60 mm. focus would equal an enlargement of 4 diameters—15 : 60.

The observer will see this image under a higher angle in proportion as he comes closer; it will then appear larger. To

do this, he must either use his accommodation or place a convex lens (eye-piece) behind the ophthalmoscope. When the eye-piece is used, a virtual image of the aërial image, still more enlarged, is produced, just as in the compound microscope. If the object-lens is withdrawn farther than its focal length from the observed eye, the image in myopia becomes larger, in hyperopia smaller, and in emmetropia remains the same. If the lens is brought closer to the eye, the image becomes smaller in myopia and larger in hyperopia.

**Ophthalmoscopy.**—The investigation of the deeper structures and interior of the eye by means of the ophthalmoscope may, therefore, be practised with (1) the direct, and (2) the indirect method.

**1. The Direct Method (Method of the Erect or Upright Image).**—The patient should be seated in a darkened room with his back to the source of illumination,—an Argand burner being suitable,—which is placed behind and to the side of his head, on a level with the ear, the face being in shadow, while the rays of light just fall upon the outer canthus of the eye. This will enable the observer to come quite close to the eye without interfering with the path of the illuminating beam. The surgeon sits at that side of the patient which corresponds to the eye under examination—for example, the right—his position being preferably on a slightly higher level than that of the subject. He now takes the ophthalmoscope in his right hand, looks through the sight-hole with his right eye, at a distance of about 50 cm. from the observed eye (the convex border of the instrument being in contact with the concave margin of his brow), meanwhile keeping the other eye open, and reflects the light into the right eye of the patient. If the left eye is to be examined, the ophthalmoscope is held in the left hand.

If the patient looks directly into the light thus transmitted, the pupil, provided this is not dilated with a mydriatic, will contract, and no view is possible. He must hence be directed to turn the head slightly to the right, and gaze into vacancy in the farthest limit of the room, when the pupil will be seen illuminated by a red glare—the reflection from the choroid

coat—bright, if the pupil is large, and dull if it is small. No details of the fundus are as yet visible at this distance (50 cm.) unless a certain grade of myopia is present or a considerable degree of hyperopia (see page 121).

The beginner should now practise keeping the light steadily in position, and may estimate the success of his endeavor by observing the glare in the pupil. If this changes in color or disappears, the light has shifted from its proper position, because the examiner has failed to retain his elbow in close con-



FIG. 49.—Ophthalmoscopic examination. Method of the upright image. Observer and patient in the correct position.

tact with his side, and allowed it to move outward and away from his body, the head meanwhile being bent to one or the other side of the vertical position it should assume in a direct line with that of the subject—feature to feature. This may be understood by observing the two accompanying illustrations (Figs. 49 and 50).

Having gained control of the light, the observer gradually approaches the eye of the patient, taking care that the red glare, which is tinted slightly yellow on the nasal side, marking

the position of the optic papilla, remains unaltered, and comes as close as possible—within one inch, or even nearer. If the manœuvre has been successful, and the light directed slightly toward the nasal side, the most prominent feature in the eye-ground—the optic nerve—will come into view; or a retinal vessel may first be manifest, and should be followed to the papilla as a stream would be to its source.



FIG. 50.—Ophthalmoscopic examination. Method of the upright image. Observer in an incorrect position.

Before proceeding to study the details of the fundus the student should make certain preliminary examinations.

(a) **Examination of the cornea and lens by transmitted light** is made by placing a +7 D or 16 D lens behind the mirror, coming close to the eye—that is, until the object to be examined is within the focal distance of the lens employed, and reflecting the light into the eye in the manner already described.

A foreign body on the cornea, a macula, a deposit on the posterior layer of the cornea, or an opacity in the lens appears as a black object against the red background, in contradis-



tion to its appearance in its true color under oblique illumination (page 60).

At the same time the mobility of the iris should be tested, and an observation made as to whether the iris reacts promptly and evenly under the influence of the light directed into the pupil at various angles.

(b) **Examination of the vitreous** is made by reflecting the light with the concave or, better, the plane ophthalmoscopic mirror, from a distance of 30 cm. into the eye, while this is moved in various directions so as to bring into view opacities which have a lateral situation or which have sunk to the bottom of the vitreous chamber.

Vitreous opacities and detached retina are seen in the erect position if the observer is sufficiently far away, because they are within his range of accommodation. Small vitreous opacities appear dark; larger ones have a grayish appearance. If he approaches closely, he must place behind the mirror a convex lens, in the manner just described, to bring them into focus, and should always use this method.

(c) **Location of Opacities in the Transparent Media.**

—If, the observer using the ophthalmoscopic mirror in the manner described in the previous paragraph, an opacity is seen to be freely movable, it must be in the vitreous. Should the opacity move only with the movement of the eye, but not spontaneously, it probably is situated in the cornea or in the lens, although it may be present in the vitreous in the form of a fixed opacity. Under these circumstances a differential diagnosis can frequently be made by means of oblique illumination. Should this method prove insufficient, the situation of the opacity may be ascertained by means of its parallax movement in relation to the border of the pupil. Fuchs states the rule as follows:

The observer looks directly forward into the eye and notes the position of an opacity within the pupillary space. Next, while the patient keeps his eye entirely quiet, the examiner slowly moves from side to side and observes if the opacity retains or does not retain the same position in the pupillary space. If the opacity retains its position unchanged, it lies in

PLATE I.



The normal fundus of the right eye examined by the direct method of ophthalmoscopy.



the pupillary plane upon or immediately under the anterior capsule of the lens. If it does not retain its original position, it is situated in front of or behind this plane—in front of the plane if the opacity moves in a direction opposite to the direction of the movement of the observing eye, and behind the plane if the opacity moves in the same direction as the observing eye. The quicker the change of position takes place, the farther is the opacity removed from the pupillary plane.

Instead of proceeding in this manner, the observer may retain his position unaltered and cause the patient to move his eye in various directions (see page 112).

When an opacity is far back in close relation with the retina, its location may be judged by noting its relation to the movement of the retinal vessels. How far forward it lies in the vitreous may be accurately measured by means of convex lenses (see page 124).

Having ascertained that the media are clear, and having approached sufficiently close, the details of the fundus oculi are brought into view and studied *seriatim*.

If either surgeon or patient is myopic, the necessary concave lens which corrects the error must first be placed in position; while, if hyperopia exists, the fundus is visible without the aid of a glass, provided the hyperopia is not in excess of the power of accommodation.

Failure to see any details, or seeing them as a blurred picture, naturally leads to the supposition that either myopia or hyperopia beyond the power of accommodation is present. Beginners, however, often fail to obtain an image of sharp definition, owing to inability to relax accommodation, and succeed in seeing the details clearly only through a concave glass. The power of relaxing the accommodation comes with practice.

**The optic nerve** appears as a nearly round or slightly oval disc, situated toward the nasal side, varying in color from a grayish-pink to a more decided red, the tint being most marked upon the nasal half, while the center is occupied by a whiter patch—the “light spot”—marking the position of the entrance and emergence of the retinal vessels. The general tint of the optic disc varies with the age and complexion of the patient

and with the intensity of the color of the surrounding eye-ground.

The papilla is bounded by two rings. The outer one, dark-colored, usually incomplete or existing only as a slight crescent of pigment upon one or the other side, is the "*choroidal ring*," and represents the border of the choroidal coat, where this is pierced by the optic nerve. Within this is a faint white stripe, more distinct in elderly people, the "*scleral ring*," which indicates the rim of the sclerotic coat, or, according to Loring, the connective-tissue elements of the inner sheath of the nerve ("*connective-tissue ring*"). The choroidal ring is often absent.

The central white patch may be noticeable only by contrasting it with the color of its surroundings, or it may be a distinct excavation, occupying the center of the disc, and having sharp borders, one of which often shelves slightly outward. This is the "*physiologic cup*," and is the space left by the radiation of the nerve-fibers toward the retina, having a floor of white color, because it is composed of the interlacing opaque fibrous tissue, or *lamina cribrosa*, which underlies the optic papilla. It is often stippled in appearance, owing to the lack of light reflected by the non-medullated nerve-fibers, which pass through the spaces of the lamina. According to Schoen, the so-called physiologic excavations are due to dragging of the vaginal processes of the optic nerve and lamina cribrosa from overexertion of the accommodation, and hence are found in adult eyes more commonly than in the eyes of children. They are usually, but not always, bilateral, and one may be larger than the other. Schweigger has traced hereditary transmission in some large physiologic excavations, but doubts if they are associated with any particular refractive condition of the eye.

**The Blood-vessels.**—From the central light-spot the *principal retinal arteries* emerge, and into it the *chief venous trunks* empty. Usually one venous and one arterial stem pass directly upward and downward, and on the edge of the disc, or a short distance from it, each divides into two branches. Sometimes this division has taken place in the axis of the

nerve behind the lamina, and two arteries and two veins appear directly in the central opening of the papilla, or *porus opticus*. The arteries traverse the surface of the eye-ground, dividing dichotomously into numerous branches, and, passing above and below, spread in greater size and number over the temporal half of the retina, sending small branches toward the macula; and in smaller size and less number over the nasal side. Fine branches arising from the central large trunks, or springing directly from the nerve, pass outward and inward, and also undergo numerous divisions.

The veins pass over the eye-ground in the same general direction as the arteries, and in close relation to them, emptying usually by means of two large branches into the center of the disc.

According to the situation of the vessels, they are named, respectively, upper and lower temporal artery and vein, upper and lower nasal artery and vein, and macular and nasal arteries and veins.

The veins are dark red in color, contrasting with the bright, natural, blood-red color of the arteries. They are slightly tortuous, and larger than the arteries in the proportion of 3 to 2. The difference in color between veins and arteries is most marked in the major branches. In the finer twigs, after four or five divisions, the distinction between arteries and veins is often possible only by tracing them to their source.

Each vessel usually presents a double contour, owing to a bright stripe which passes along the center, leaving a red line on either side. This so-called "*light-reflex*" is a condensation by the refractive action of the blood column of the rays of light which have passed through the vessel from in front, and have been reflected back slightly from the posterior wall, but chiefly from the underlying tissues.<sup>1</sup> It is more marked upon the

<sup>1</sup> The cause of the light streak was usually attributed to reflection from the anterior surface of the vessel-wall or the anterior surface of the blood column, until Loring's investigation showed that the *refraction of light* was the chief cause of the phenomenon. Loring's conclusions have received experimental confirmation in the interesting research of Achilles E. Davis. Story rejects Loring's theory, and assumes that the reflex comes from the vessel-walls.

arteries than upon the veins, and, indeed, is often absent as the latter cross the disc, being visible in a minor degree when they lie at some distance in the retina.

*Pulsation*—that is, alternate expansion and contraction of the vessels—does not occur in the retinal arteries under normal circumstances. It may be called into existence by pressing lightly with the finger on the globe, and is seen under pathologic conditions—for example, in glaucoma and heart disease.

*Pulsatory locomotion*—that is, the bulging of the arch of a sharply curved large retinal artery in the region of the papilla with the heart systole—may be seen in normal eyes, as Haab has pointed out.

Spontaneous pulsation in the veins is a frequent phenomenon. Lang and Barrett found it in 73.8 per cent., Veasey in 58.3, and the author in 62.1 per cent. of the cases examined. It may be produced by a slight pressure upon the globe. The spontaneous pulse is due to a communication of the arterial pulsation to the vein, as these vessels lie side by side in the optic nerve, or may be explained by the theory of Donders, that during the systole of the heart (diastole of the retinal arteries), an increased tension in the vitreous is communicated to the walls of the retinal veins, especially the larger ones, at their exit from the eye where the least resistance is offered, obstructing the flow of blood and compressing their lumen. The blood coming from the capillaries overcomes this resistance and the vessels regain their caliber, alternate collapse and distention thus being produced. According to Türk, the venous pulse is due to a continuation of the arterial pulse-wave through the capillaries into the veins.

**Physiologic Variations.**—The *papilla*, instead of being round or slightly oval, with a vertical long axis, is often distinctly irregular in outline, or has its long axis in a horizontal or oblique direction. Its outer half may be embraced by a crescent of greater or less choroidal-changes, the so-called *conus*. A congenital crescent of white appearance, the *underlying conus*, may sometimes be seen below (see page 511).

The *physiologic cup* varies in size, area, and depth. Normally situated on the temporal side, it may be a deep pit,

funnel shaped, with overhanging margins over which the vessels sharply bend, or very shallow and dish-like, sloping to the temporal side, or deep and sharply marked on its inner side, but shading outward.

The *distribution of the vessels* is subject to numerous variations—so much so that it would be difficult to find it the same in any two eyes. The usual departure from the ordinary type is the one already referred to, in which four major branches (two arteries and two veins) appear at the center of the porus, instead of two large branches which later divide at or near the margin of the disc. Anomalies of the veins upon the disc, in the form of unusual bifurcations, are occasionally seen. Divisions of the vein just before entering the disc; division at the margin; the formation of a vascular circle and final reunion in a single vessel; and anastomosis of the central vein with an aberrant vein, or one which has penetrated the inner side of the disc, have been described (Randall). The veins are normally more tortuous than the arteries. Both sets of vessels present this appearance in marked degree as symptoms in certain pathologic conditions, but also occasionally as an anomaly without such significance (Nettleship). Again, the vessels may stand forward from the disc in a high curve, or twine around each other, as we sometimes see two stems on a vine.

An anomaly of not infrequent occurrence (7 to 10 per cent. of examined eyes) is a *cilioretinal vessel*, usually, according to Elschnig, an artery, which appears at the temporal border of the disc, then arches outward or away from the papilla, enters the retina, and pursues a general course toward the macula. A large cilioretinal vessel may take the place of one of the temporal arteries. According to Elschnig, a cilioretinal vessel may be a primary branch of a ciliary artery which pierces the sclera obliquely, without sending a branch to the choroid, and then enters the intrascleral or intrachoroidal part of the optic nerve, or an offset of a ciliary vessel which primarily enters the choroid, where it divides, and one branch passes on into the retina and produces the anomaly in question. *Optico-*



*ciliary vessels* do not reach the retina, but disappear at the disc's border.

**The Retina.**—Inasmuch as the retina is practically transparent, a study of this membrane is hardly possible without a consideration of the underlying choroid and even the sclera.

In certain persons, especially of dark complexion, the retina assumes a grayish tint in the neighborhood of the papilla, most marked upon its nasal half. This faint opacity is slightly streaked, the striations indirectly corresponding to the expansion of the optic nerve-fibers. Eyes long subjected to the strain of uncorrected ametropia furnish an exaggerated picture of this appearance, which, if at all extensive and associated with similar opacities along the lines of the vessels, assumes pathologic importance (see Retinitis).

In the eye-ground of young subjects, particularly along the line of the vessels, numerous wave-like, glistening reflexes may be seen to follow one after another with the slightest movements of the ophthalmoscopic mirror. The effect is similar to the shimmer seen on the surface of certain silks, and has been designated by English writers "*shot-silk retina*." It is unusual to find the phenomenon in individuals over thirty, its occurrence being marked in direct proportion to the youth of the subject.

**Macula Lutea.**—About two discs' diameter to the outer side of the papilla, and slightly below the horizontal meridian, there is a circular, or slightly oval spot, equal in area to the end of the optic nerve, darker in color than the surrounding fundus, uncrossed by any visible retinal vessel, but toward which the finer twigs of the major branches radiate, fringing its boundary. This region is the *macula lutea*, or *yellow spot*, and is that portion of the eye-ground concerned with the functions of direct vision.

Its center is occupied by the *foveal reflex*, which marks the edge of the *fovea centralis*, and which may appear as a spot of light, a small circle with reddish center, a shifting crescent, or a shining line. This, in turn, is surrounded by a dark area (the dark spot of the macula), sometimes containing a number of brownish-black or light-colored or even glistening granules,

often called *Gunn's dots*, which have no pathologic significance. Finally, the margin of the macula is bounded by a glistening, *whitish ring or halo* (macular reflex).

The method of examination determines whether all these characteristics of the macula lutea can be observed. They are fairly constant, however, with the exception of the halo, and are notable in young children. Ordinarily the macular ring is best seen with the indirect image in young eyes, when it is apt to assume an oval shape; but according to Lindsay Johnson, even with the upright image, if the source of illumination be gradually lowered, a time is arrived at when more light is reflected from the macula than from the general fundus, and at that moment the ring appears. In elderly people the region usually cannot be well recognized except by the absence of vessels and its darker color, but even in them careful focusing will not infrequently reveal the foveal reflex. In albinos it is still more difficult to define this area.

Although no vessels visible to the ophthalmoscope cross the macula, except as an anomaly (Randall, Johnson), the region is abundantly supplied with capillaries, which can be shown by artificial injection, which surround the fovea in a close loop, but do not occupy it. The student may find the region difficult to study because the light falling upon it causes the pupil to contract, the view being further hindered by the corneal reflex. Hence the pupil should be dilated, when the macula may be brought into view by requiring the patient to look directly into the ophthalmoscopic mirror, or may be found by turning the light outward from the lower edge of the disc. The region should always be studied with the utmost care.

The appearances in the macula depend partly upon the disposition of the layers of the retina in this region. At its margin the retina is much increased in thickness by an extra development of the layer of the ganglion cells, while the fovea is produced by the hollowing out of the center of the macular region. The macular reflex, or ring, therefore, may be considered as a reflection arising from the thickened macular circumference, and the foveal reflex as a reflection from the edge of the fovea. The

variations, according to Johnson, are due to the direction and the shape of the sloping sides of the pit, but, according to Dimmer, depend upon the kind of ophthalmoscopic mirror which is employed, the reflex being the inverted image of the center of the mirror. According to Piersol, the color of the macula depends upon the presence of a yellowish pigment within the layers internal to the visual cells, the latter elements remaining colorless; in consequence of this arrangement the fovea, in which the neuro-epithelium alone exists, is devoid of pigment, and, therefore, appears as a light spot within the colored area. The dark-brown spot of the macula is generally believed to depend upon the thinning of the retina at this spot, with a more decided pigmentation in the epithelium. Dimmer, however, thinks that it is also produced by absence of the slight veiling of the retina at this point, which is manifest in the surrounding more compact layers.<sup>1</sup>

**The Choroid.**—The bright glare which illuminates the pupil when the light is thrown into it from the ophthalmoscopic mirror, and develops into the uniform red color of the fundus, when this is brought into view, arises from the choroid. The rays of light pass through the transparent retina to its pigment epithelium, which in ophthalmoscopic work is accredited to the choroid, and in part are absorbed and in part reflected. The greater the quantity of the pigment, the greater the amount of absorption, so that the color of the eye-ground depends upon the degree of saturation in this epithelium, and varies from an almost slaty color in the dark-skinned races to a dark red in persons of blonde complexion. A light yellowish-red or brownish color is often evident.

In very fair people the imperfect development of pigment-cells of the choroid exposes the larger choroid vessels, which are evident as a meshwork of tortuous red bands with intervening spaces of lighter or darker color, and which are dis-

<sup>1</sup> Those interested in this subject should consult *Die Ophthalmoskopischen Licht-reflexe der Netzhaut*, by Dr. Friedrich Dimmer, Vienna, 1891; an excellent article by Dr. G. Lindsay Johnson, entitled "Observations on the Macula Lutea," *Archives of Ophthalmology*, vol. xxi.; and "The Region of the Macula Lutea in Ophthalmoscopy," by Dr. M. F. Weyman, *Ophthalmic Record*, vol. ii., page 219.

tinguishable from the retinal arteries and veins by their flat appearance and absence of the light streak. The most nearly perfect exposure of the choroidal vessels is seen in albinos. It is not usually possible with the ophthalmoscope to differentiate the arteries and veins of this system, although the latter are of greater size, and, near the equator of the eye, converge toward the *venæ vorticosæ*, being separated by larger and longer spaces. In decided brunettes these spaces are more deeply tinted than the vessels which appear "like light streams separated by dark islands" (Nettleship). A fair general idea of what tint may be expected in the fundus may be obtained by observing the color of the patient's hair.

All the details of the eye-ground may be studied with greater ease through a dilated pupil, and, on beginning his studies, the student may with propriety employ a mydriatic, euphthalmin, cocain, or homatropin, not atropin, provided no signs of glaucoma are present. Having acquired knowledge of the normal appearance thus seen, he must now practise with the undilated pupil.

The disc and macula having been studied, the peripheral parts of the eye-ground should be examined by throwing the light inward, upward, and downward, the head of the observer being moved correspondingly to comply with the changed direction of the mirror. Even when the central part of the fundus presents the usual characteristic red tint, the choroidal vessels are frequently exposed in the periphery, presenting the appearance just described, and having no pathologic significance.

**Determination of Refraction by the Ophthalmoscope.**—The estimation of the refraction of the eye by means of the ophthalmoscope results in either a *qualitative* or a *quantitative* determination.

The former is obtained in the following manner: Hold the ophthalmoscope 30 to 50 cm. from the patient's eye, and, looking through the central aperture of the mirror, unaided by a glass, observe if any vessels come into view. Their appearance means that the eye is either hyperopic or myopic. Now move the head from side to side, and note if the vessels move

apparently in the same or in a direction opposite to the movements of the head. If the former, the eye is hyperopic; if the latter, myopic. Inasmuch as the image of the vessels in low degrees of myopia would be formed only at a considerable distance from the observed eye (30 to 120 cm.), and since no sharp image would be obtained in either emmetropia or low degrees of hyperopia farther away than 30 cm., any considerable degree of ametropia may be excluded by failure to obtain a direct image except at a long range or a very short distance from the patient's eye.

Before attempting a *quantitative* estimation of the refraction by means of the ophthalmoscope, certain fundamental rules must be observed:

*1. Both surgeon and patient must have relaxed accommodation.*

The ability to relax the accommodation comes with practice, and is best secured for the patient by requiring him to gaze inattentively into the farthest corner of the well-darkened room.

*2. A certain definite spot in the eye-ground upon which to focus should be selected.*

Naturally the macula, or region of accurate sight, would seem to offer the most desirable point; but, owing to the difficulty of making accurate observation through the undilated pupil, which contracts when the light falls upon this region, and the dazzling corneal reflex, it does not serve a satisfactory purpose; hence it is better to select the edge of the optic disc, or the medium-sized vessels midway between the disc and the macula, where two branches, running at right angles to each other, may readily be found.

*3. The observer should approach as close as possible to the eye under observation.*

If he is able to place with the ophthalmoscope a correcting lens at a point 13 mm. in front of the cornea, he has reached the anterior focal point of the eye, and the power of such lens would express the degree of ametropia, and be equivalent to one set in a frame which had been found by the usual tests to neutralize the refraction error. If he is unable to reach this point, and holds the ophthalmoscope with the correcting lens

## Determination of Refraction by Ophthalmoscope 123

at a point farther away from the cornea than 13 mm., the distance between the glass and the cornea must be subtracted from the focal distance of the correcting lens, in order to ascertain the real amount of hyperopia, and be added to the focal distance, to obtain the degree of myopia.

4. *In order to ascertain correctly the refraction error, the observer must be emmetropic, or, if not, render his eye emmetropic by using the proper correcting lens, in the form either of spectacles or of an equivalent glass placed behind the sight-hole of the ophthalmoscope.*

The emmetropic observer can see the details of the myopic eye-ground only dimly without the aid of a correcting glass, and not at all if the myopia is of high degree. By placing concave glasses behind the sight-hole of the ophthalmoscope, the convergent rays which leave the observed eye are rendered less and less convergent, until that glass is reached which just yields a distinct image—*i. e.*, one which has rendered the convergent rays parallel.

The emmetropic observer can see the details of a hyperopic eye-ground distinctly without the aid of a correcting glass, unless the hyperopia is of very high degree, by an effort of accommodation which renders his crystalline lens more convex, and thus causes the divergent rays which leave a hyperopic eye to become parallel. But, with accommodation relaxed, he sees distinctly the details of the fundus through a convex lens placed behind the ophthalmoscope; this should be substituted for other stronger convex lenses until the strongest one is reached with which a clear image is still possible—*i. e.*, one which has rendered the divergent rays parallel, while the next highest number creates a blur over the details of the eye-ground.

From what has been said it follows that the strongest convex lens, placed in position in the ophthalmoscope, with which the emmetropic observer can still see the details of the fundus at the point selected measures the degree of hyperopia; the weakest concave lens, the degree of myopia. The hyperopia usually is somewhat greater, and the myopia somewhat less, than the result obtained by ophthalmoscopic examination.

In order to estimate the refraction of the eye examined, the hyperopic observer must subtract from the convex, or add to the concave, lens, which yields him a sharp image of the fundus, the amount of his own error, while the myopic observer must add to the convex, or subtract from the concave, lens, with which he sees by the eye-ground the degree of his own near-sightedness.

In order to calculate the amount of lengthening or shortening of the eye equal to a lens which neutralizes the myopia or hyperopia in any given case, and provided the distance between the surgeon's eye and that of the patient is not more than 2.5 cm., the following table, which is taken from Nettleship, and which he has altered from Knapp, is useful:

Hyperopia of 1 D represents a shortening of . . . . .					0.3 mm.
"	2	"	"	"	. . . . . 0.5 "
"	3	"	"	"	. . . . . 1 "
"	5	"	"	"	. . . . . 1.5 "
"	6	"	"	"	. . . . . 2 "
"	9	"	"	"	. . . . . 3 "
"	12	"	"	"	. . . . . 4 "
"	18	"	"	"	. . . . . 6 "
Myopia of 1 D represents a lengthening of . . . . .					0.3 "
"	2	"	"	"	. . . . . 0.5 "
"	3	"	"	"	. . . . . 0.9 "
"	5	"	"	"	. . . . . 1.3 "
"	6	"	"	"	. . . . . 1.75 "
"	9	"	"	"	. . . . . 2.6 "
"	12	"	"	"	. . . . . 3.5 "
"	18	"	"	"	. . . . . 5 "

By this table the depth of an excavation in the papilla may be measured. For instance, if the bottom of the pit required  $-5$  D for its sharp examination, and the margin of the nerve was seen without any glass, the depth of the excavation would be 1.3 mm.

The presence of *astigmatism* may be ascertained by means of the ophthalmoscope and the upright image, and, in skilled hands, its amount measured with reasonable accuracy.

In all such examinations the instrument must be close to the eye and in an exact perpendicular line, and the following points observed:

## Determination of Refraction by Ophthalmoscope 125

(a) The optic disc is an ellipse, its long axis corresponding with the meridian of the greatest refraction, and its short axis with the meridian of least refraction. When the principal meridians are vertical and horizontal, the disc usually is a vertical oval, more rarely a horizontal oval.

When the principal meridians are inclined, they sometimes correspond to the direction of the long and short axes of the ellipse assumed by the nerve-head. As, however, the disc is often oval in non-astigmatic eyes, this evidence is not satisfactory.

(b) All points of the portion of the fundus under examination are not in focus at the same time—*e. g.*, the retinal vessels running in the directions which correspond to the principal meridians.

Thus, when two vessels cross each other at right angles, the vertical branch may be sharply seen, while the horizontal one presents a blurred image, or the upper and lower margins of the disc may be clear, but the lateral borders indistinct. The amount of hyperopia or myopia of the *vertical* meridian is equal to the strongest convex, or weakest concave, glass which makes distinct the vessels running in a *horizontal* direction. The refraction of the *horizontal* meridian is determined by the glass which yields a clear image of the vessels running in a *vertical* direction. As the vessels do not correspond to the layer of the rods and cones, the measurement is an approximation.

If a vertical vessel is sharply seen with a convex lens of 3 D, while the vessels at right angles to it are clearly visible without the aid of any glass, and blurred by the addition of a convex one, hyperopia of 3 D exists in the horizontal meridian, because a line—in this case a vessel—appears most distinct in the meridian of greatest ametropia, inasmuch as it is seen by means of the rays passing through that meridian of the cornea which lies at right angles to its course (see Fig. 51). If, in another eye, the vertical vessels appear distinct without the aid of a glass, and the horizontal vessels require a concave lens of 3 D to bring them into focus, myopia of 3 D exists in the vertical meridian. In the one instance there is *simple*



*hyperopic astigmatism*, which would require a  $+3$  D cyl., axis vertical, for its neutralization; and in the other, a *simple myopic astigmatism* demanding a  $-3$  D cyl., axis horizontal, for its correction.

*Compound astigmatism* is determined by finding, in hyperopia, the strongest convex lens which the vessels in each meridian will bear with the preservation of a distinct image, and subtracting the one from the other, thus finding the difference between the meridians—*i. e.*, the amount of astigma-

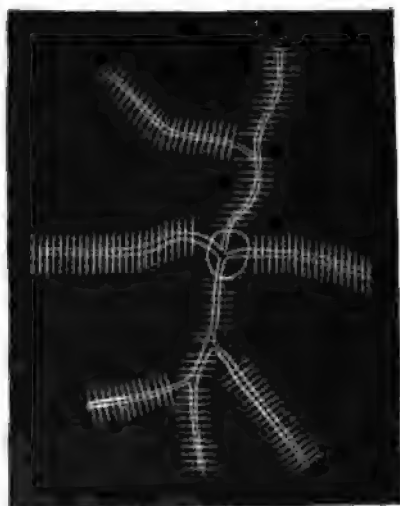


FIG. 51.—Focusing of the vessels by the meridians of an astigmatic eye; the parallel lines on each vessel represent the direction of the meridians through which a distinct image of the vessel is obtained.

tism. Thus, if the vertical vessels remain in focus when viewed through a  $+3$  D lens, and the horizontal vessels through a  $+1$  D, there is a general hyperopia of  $1$  D, with a difference of  $2$  D between the principal meridians. This difference of  $2$  D represents the amount of the astigmatism. In the same way myopia of varying amounts in each meridian is measured. The correcting glass in the first instance would be  $+1$  D sph.  $\odot$   $+2$  D cyl., axis vertical.

If the vertical vessels are distinctly seen with  $+3$  D, while the horizontal vessels require a  $-1$  D for their perfect detec-

tion, myopia of 1 D exists in the vertical meridian, and hyperopia of 3 D in the horizontal meridian. There is an astigmatism in this case of 4 D. The principal meridians are respectively myopic and hyperopic, constituting what is termed *mixed astigmatism* (compare page 172).

The measurement of astigmatism in this manner, with any degree of accuracy, requires a vast amount of practice, a perfect control of the accommodation, and even then must never be employed to the exclusion of other and more trustworthy methods.

**2. The Indirect Method (Method of the Inverted Image).—**

The patient and surgeon are seated in the same relative positions as have already been described in connection with the direct method, and, if the right eye is to be examined, the ophthalmoscope is held in the right hand at a distance of 30 cm. from the patient, who is instructed to look at the right ear of the examiner. A convex lens of 20 D, held between the surgeon's left thumb and index-finger, while the remaining fingers are rested upon the brow to steady the hand, is placed at about its own focal length in front of the patient's eye, directly in the path of the rays returning from the fundus, which are thus brought to a focus and form an aërial image between the observer and the glass.

If the left eye is to be examined, the ophthalmoscope is held in the left hand, and the patient instructed to look at the surgeon's left ear, while the lens, grasped in the fingers of the right hand in the manner just described, is placed in position.

Much practice is required to gain perfect control of the illumination, and at the same time to keep the ophthalmoscope, lens, and patient's eye in proper relation. This is largely due to the difficulty of securing perfect accord between the relative positions of the two hands. While the beginner endeavors with one hand to place the lens properly before the patient's eye, his attention for the moment is distracted from the other hand, which holds the ophthalmoscope, and this becomes unsteady and permits the light to shift from the pupillary area.

This difficulty having been overcome, facility in using the supplementary lens, or, as it is often called, the object-glass,

must be acquired, especially to avoid the confusing reflexes from its surfaces and the magnified image of the iris. This is best accomplished by holding it in a slightly oblique direction, and at a point a little farther away from the cornea than its own focal length. The glass should now be moved up and down, back and forth, to obtain alterations in focus and displacements of the image from side to side, and a parallax between points situated at different levels in the eye-ground.



FIG. 52.—Method of an indirect examination with the ophthalmoscope.

The image which is found at a certain distance in front of the object-glass may not present itself to the observer as a distinct picture, owing to his inability to accommodate for the point of its formation. This accommodative strain may be relieved, and the image magnified by placing behind the ophthalmoscope a convex glass of 5 D, which adapts the emmetropic observer, with relaxed accommodation, for a point 20 cm. distant. If the observer is presbyopic, or has a deficient amplitude of accommodation, this additional lens is absolutely necessary; while if he is hyperopic, the degree of his hyperopia should be added to the glass used as a magnifier. The observer possessing a moderate degree of myopia requires no

lens in the ophthalmoscope, because he views the aërial image at his far point, while if his myopia is of high grade, he will need a weak concave glass.

If, then, the examiner, having illuminated the pupil from a distance of 30 to 50 cm., finds the slightly yellowish area in the general red glare, indicating the position of the optic papilla, and places the convex lens (object-glass) in position and the second convex lens (eye-piece) behind the ophthalmoscope and secures an aërial image, he will observe the following characteristics in contrast with the appearances seen by the direct method; always remembering that the picture is inverted, and that what apparently is on the nasal or inner side really belongs to the outer or temporal side; that what apparently is below really is above:

*1. The field is larger.*

Not merely the object—the optic nerve, for example—comes into view, but also a portion of the surrounding eye-ground, precisely as a more extensive portion of the field of the microscope is obtained through an objective of low power than through one of high power.

*2. The individual objects in the field are smaller and more sharply defined, but the finer details are less perfectly revealed, because seen under a lower magnifying power.*

The relation between the extent of the fundus visible and the size of the details depends upon the strength of the supplementary convex lens (object-glass). If this is strong, the expanse of the field brought into view will be greater, while the component parts will be smaller (Loring). Hence if it is desired to enlarge the image of the fundus at the expense of its extent seen at one time, instead of a 20 D convex glass, one of 10 D should be employed.

*3. The differentiation between objects of similar appearance—e. g., the vessels—is less perfect.*

Working under these conditions, the student will observe that the optic papilla is smaller, its edges more sharply defined, and the faint veiling of the nasal margins caused by the striation of the surrounding retina less noticeable.

The difference between veins and arteries is not so marked.

as with the direct method, and it may be well-nigh impossible to distinguish from each other the finer twigs of each system. As a rule, the veins, being larger and darker, present a more distinct image than the arteries, which are slightly blurred in outline. The light streak, so noticeable in the upright image, is frequently wanting.

The macular region, especially if the pupil is not dilated, presents unusual difficulties in its study. If the patient is required to look directly into the ophthalmoscope, this illumination of the macula causes a contraction of the pupil (if the iris is not under the influence of a mydriatic), and brings into existence confusing reflections. It is best brought into view by first finding the papilla and then moving the object-glass horizontally across the line of vision until its inner margin corresponds with the outer border of the pupil. In young subjects a bright reflex encircles an elliptic dark area containing in its center a reddish or, less frequently, a bright point surrounded by a small brilliant ring. These characteristics are sometimes lacking in adults, and may not be present in children. Under these circumstances the macula is distinguishable only by the ill-defined appearances of a darker tint and an absence of vessels (see page 118).

#### **Estimation of Refraction by the Indirect Method.**

—A *qualitative* estimation of the refraction may be ascertained with the mirror alone, in the manner already described (page 121). Furthermore, ametropia of high degree may be recognized by varying the distance of the object-lens from the eye. Withdrawal of the lens from the eye causes the image to appear smaller in hyperopia, larger in myopia.

The measurement of the degree or quantity of the refraction by the indirect method may be attempted by ascertaining the exact distance of the image from the object-lens, a screen being placed at that point where the inverted image is most distinct, but the method does not yield results of practical value.

Schmidt-Rimpler has devised a means for measuring the refraction by the indirect method in which the position of the inverted image of the eye-ground—that is, the distance of

the image from the auxiliary lens—is ascertained by means of a special apparatus.

The existence of *astigmatism* may be determined with the indirect method by observing the changes which take place in the shape of the optic nerve, as the refractive condition of the eye varies in its different parts. In the direction of least refraction the image of the nerve contracts as the lens is withdrawn; in the direction of greatest refraction the image of the nerve expands; in the absence of astigmatism the round or oval shape of the nerve is not altered, whether the lens is held close to the eye or is removed from it. For practical purposes, however, the methods of determining the refraction of the eye with the aid of the inverted image do not enjoy material advantages, and the accuracy of the results cannot be compared with those obtained by skiascopy, the trial-lenses, and ophthalmometry.

**Ophthalmometry.**—This term indicates mensuration of the eye, and, as usually employed, is limited in its application to the measurement of the radius of curvature of the cornea (*keratometry*). In order to practise ophthalmometry, instruments for taking the measurement of the radius of curvature of cornea have been devised, and are known as *ophthalmometers*. The ophthalmometer most in use is the one devised by Javal and Schiötz.

Other instruments are those designed by Leroy and Dubois, Reid, and Hardy. In the opinion of the author, the ophthalmometer of Javal and Schiötz or the new model of Hardy is of the greatest service in determining the refraction of the cornea and the direction of its principal meridians. Neither of these instruments should be used to the exclusion of other methods, especially the employment of mydriatics and skiascopy. (For a full description of the method of using the ophthalmometer see Appendix, page 736.)

**Optometry** is a term which indicates the principles involved in the measurement of the refraction of an eye by its limits of distinct vision. The instrument which thus serves to determine the refraction of the eye is called an *optometer*.

Optometers are based upon a number of principles. For

instance, a single convex lens by which the direction of the luminous rays emanating from an object is changed, and consequently the determination of the refraction of the eye rendered possible, constitutes an optometer. Other optometers are based upon the principle of a telescope; still others upon the measurement of circles of diffusion, upon Scheiner's experiment, and upon the chromatic aberration of the eye. It would not be possible, in the limits of this manual, to describe in detail the principles involved or the various forms of apparatus which have been employed. Should the student desire to pursue the subject, he may with advantage consult the chapter devoted to this method found in Landolt's *Refraction and Accommodation of the Eye*.

**Skiascopy, or the Shadow-test (Retinoscopy).<sup>1</sup>—**

This is a method of determining the refraction of the eye by observing the direction in which the light appears to move across the pupil, when it is made to move back and forth across the face by rotation of the mirror which reflects it to the eye.

With the ophthalmoscope, as has already been explained, the observer may look into a myopic eye from close in front of it and see an erect image of the fundus, which he can render clear by the proper concave lens; or, in the same eye, from a greater distance, he can view an inverted image of the fundus, with or without the intervention of a convex lens. The point at which the change from the erect to the inverted image occurs has been called the *point of reversal*. It is the point for which the eye is focused, and is the far point of distinct vision. Skiascopy is simply an accurate method of determining this point of reversal.

To apply the test with the plane mirror the surgeon faces the patient at a distance of about 1 meter or less; and, holding the mirror to his own eye, reflects on the patient's face the light from a lamp placed near the mirror, and covered with an opaque shade having an aperture 5 to 8 mm. in diameter. By rotating the mirror the area of light it throws on the face is made to move up and down, or from side to side, or obliquely.

<sup>1</sup> This section has been prepared and revised by Dr. Edward Jackson.

The part of the light that falls on the patient's pupil is condensed on his retina, forming there a small light area which also moves as the mirror is rotated; for the plane mirror this retinal light area always moves in the same direction as, or "with," the light on the face.



FIG. 53.—Skiascopy with the plane mirror.

In Fig. 53  $L$  represents the lamp-flame, screened from the patient, and  $A$  and  $B$  two positions of the plane mirror. When the mirror is at  $A$ , the light that enters the eye will come as though from a flame at  $l$ , and will be condensed toward  $a$ , on the lower part of the retina. At this time the light

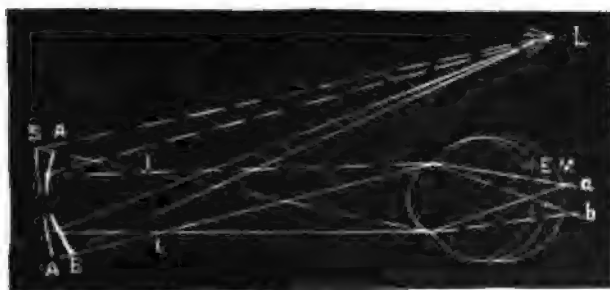


FIG. 54.—Skiascopy with the concave mirror.

falls on the lower part of the face. But when the mirror is rotated to  $B$ , the light entering the eye comes from the direction  $l'$ , and is condensed toward  $b$ , on the upper part of the retina. At the same time the light on the face moves upward. The positions of the retina in hyperopia, emmetropia, and myopia are shown at  $H$ ,  $E$ , and  $M$ . It will be noted that in all these forms of ametropia the movement of the light on the retina is *with* the light on the face. When



skiascopy is practised with a concave mirror, the lamp-flame which serves as a source of light must be placed behind the patient; and the light area on the retina moves in an opposite direction "against" the light on the face, "against" the movement of the mirror.

In Fig. 54 the action of the concave mirror is represented. When the mirror is at *A*, the light that enters the eye comes from the focus of the mirror at *f*, conjugate to the position of the lamp-flame, and is condensed toward *a*, on the upper part of the retina; and when the mirror is at *B* the light enters from *f'*, the new position of this conjugate focus, to be condensed toward *b*, on the lower part of the retina—that is, as the light has moved upward on the face, it has moved downward on the retina, and this is true for either *H*, *E*, or *M*.

The following account assumes the use of the plane mirror,



FIG. 55.—Rays coming from a myopic eyeball.

but will apply equally for the concave mirror, if one bears in mind that with the latter the movement in the pupil is always in the opposite direction, and that the lens before the patient's eye must be changed, instead of changing the surgeon's distance from the patient (see page 139).

We have thus seen what is the *real* movement of the light on the retina, as it would appear in the back of an enucleated eye with the sclera and choroid removed, but the surgeon does not see it in that way; he can only watch the *apparent* movement as seen through the pupil. This will be the same as the real movement, with the light on the face [plane mirror] when he sees an erect image, and in the opposite direction when he sees an inverted image.

In Fig. 55 *M* represents a myopic eyeball, from the retina

of which rays come out and are focused at *B*, the *point of reversal*. Anywhere closer to the eye than this, as at *A*, an erect image is seen; the light in the pupil seems to move *with* the light on the face. Anywhere beyond the point of reversal, as at *C*, an inverted image will be seen, and the light in the pupil will appear to move *against* the light on the face (see page 155). Just at the point of reversal *B* it is impossible to see which way the light moves, and the illumination of the pupil is very feeble.

At one or two diopeters from the point of reversal the light is comparatively bright. As the examiner goes farther than this from the point of reversal, it becomes more and more feeble. With the same movement of the mirror the apparent movement of the light in the pupil is quicker as the point of reversal is approached. These variations in the degree of illumination and rapidity of movement may aid the expert in choosing the lens to be next placed before the eye, but the thing mainly depended on is the direction of the movement.

**Application in Myopia.**—If the surgeon, on throwing the light into the eye, finds that its apparent movement in the pupil is *against* the light on the face, he must be farther from the eye than the point of reversal (*B*, Fig. 55). He should then slowly approach the patient, still rotating the mirror and watching the apparent movement of the light, until he finds this apparent movement is *with* the light on the face, as at *A*. He is now closer to the patient than the point of reversal, and should draw back and observe the greatest distance (*A*) at which this movement with the light on the face can be distinguished; then, drawing farther back, he observes the nearest point to the eye (*C*) at which the inverted movement can be seen, and the point *B*, half-way between *A* and *C*, is to be taken as the point of reversal. These observations should be repeated until the exact position of *B* is established. The distance from *B* to the eye is then measured; it is the focal distance of the glass required to correct the myopia. For instance, if the erect movement is seen as far as 55 cm. from the eye, and the reversed movement as near as 80 cm.,

the point of reversal will be about 67 cm., and the myopia, therefore, 1.50 D.

If the myopia thus discovered is high, its amount can be most accurately determined by putting on a concave lens that will correct all of it but 1 or 2 D, measuring what is left by skiascopy, and adding this to the strength of the lens used to get the total myopia.

If, on the other hand, the myopia is very low, the point of reversal may be at so great a distance that when near it one cannot see which way the light is moving in the pupil. In this case a weak convex lens must be placed before the eye, the point of reversal found with the lens, and then the strength of the lens deducted from the myopia which this indicates in order to find the myopia of the eye.

**Application in Hyperopia.**—Here the rays from the retina emerge divergent, as shown by the broken lines in Fig. 56, and there can be no point of reversal anywhere in front of the eye. The surgeon finds the apparent movement of the light in the pupil is *with* the light on the face, and it continues to be so, no matter how far he draws back. It is necessary, then, to place a convex lens  $L$  before the eye, strong enough to render the rays convergent, and so to make a point of reversal, a convenient distance in front of the eye. This lens does two things: First, it overcomes the divergence of the rays; this takes part of its power. Second, the remainder of its power makes the rays converge, causing a sort of artificial myopia. The point of reversal ( $B$ ) obtained is the point of reversal for this artificial myopia. It is to be determined as for natural myopia, and the amount of myopia it represents deducted from the total strength of the lens. The remainder will be the power required to overcome the divergence of the rays, or the strength of lens needed to correct the hyperopia.

For example, suppose the movement of the light in the pupil is found at all distances to be *with* the movement of the light on the face, and on placing a 5 D convex lens before the eye it is found to be still *with* the movement of the light on the face when the examiner approaches to a little within 1 meter, but appears reversed if looked at from a distance slightly

greater than 1 meter. The point of reversal then is at 1 meter; 1 D of the strength of the lens is making the rays convergent, while the other 4 D have been used to overcome the divergence of the rays as they came from the eye. Therefore the eye must be 4 D hyperopic. For accuracy it is better here, as in the case of natural myopia, to make the final determina-



FIG. 56.—Rays emerging from a hyperopic eye.

tion with a lens that brings the point of reversal  $\frac{1}{2}$  to 1 meter from the eye.

**Application in Emmetropia.**—The application of skiascopy for emmetropia is precisely the same as for hyperopia; but it is found that the artificial myopia caused by the convex lens equals the full strength of the lens, proving that the rays must have emerged from the eye parallel.

**Application in Regular Astigmatism.**—The principles involved and the methods to be employed are essentially the same as in myopia or hyperopia; but the refraction has to be determined in the two principal meridians, instead of in any meridian indifferently, as it can be where all meridians are alike. To determine the refraction in a certain meridian the light must be made to move back and forth in that particular meridian, by rotating the mirror about an axis at right angles to it.

The direction of either of these principal meridians is revealed by the area of light in the pupil assuming the form of a more or less distinct *band of light*, extending across the pupil in the direction of this meridian, when its point of reversal is approached. This band can be clearly distinguished only when the surgeon's eye is much nearer to the point of reversal for one principal meridian, than to the point of reversal for the

other principal meridian. In such a position this band is, for the higher degrees of astigmatism, very noticeable, and fixes with the greatest accuracy the direction of the principal meridian. When the band-like appearance is most noticeable, it is easy to cause its apparent movement from side to side; but it is more difficult to distinguish the movement in the direction of the length of the band. Still, this latter movement is the one that must be especially watched, and its reversal point determined.

When the astigmatism is very low, the appearance of a band may be very indistinct, or not at all perceptible. But in such cases it will be found that when the surgeon has reached the point of reversal for movement of the light in one direction, there is still distinct movement, either direct or inverted, in the direction at right angles to this; and he will thus know he has tested one meridian of an astigmatism, and must in the same way ascertain the point of reversal for the other at right angles to it. When the surgeon is closer to the eye than the point of reversal for either meridian, the movement will be *with the light on the face in all directions*. When he is at the point of reversal for the meridian which has its point the nearer to the eye, there will be *no distinguishable movement in the direction of the band* here visible, but still a *movement with at right angles to it*. When he is between the two points of reversal, there will, in the direction of the nearer meridian, be an inverted movement of the light (*movement against*), but in the other meridian a direct movement (*movement with*). When the farther point of reversal is reached, the *direct movement* in its meridian *ceases*, while the movement in the other meridian continues inverted (*against*). When the surgeon has drawn back beyond both points of reversal, the movement is reversed, *against the light on the face in all directions*.

Having determined the amount of myopia, natural or artificial, in both principal meridians, the strength of the cylinder required to correct the astigmatism will, of course, be the difference between the refraction for the two meridians. Having thus ascertained it, it is well to put this cylinder before the eye and to see if it does accurately correct the astigmatism,

giving the same point of reversal for all meridians of the cornea; and, for accuracy, the spheric lens which will bring this point of reversal to the distance of  $\frac{1}{2}$  to 1 meter should be used with it.

**Application in Irregular Astigmatism.**—If the pupil is dilated, it will always be found that the refraction of the eye varies in different parts of it, so that points of reversal for different parts of the pupil lie at different distances in front of the eye; and at the point of reversal and near it, both direct and reversed movements of the light are visible at the same time in these different parts of the pupil. Usually there is at the center of the pupil a considerable area that has about the same point of reversal, called the *visual zone*. This is the part through which light will come to be focused on the retina when the eye is in use. For practical purposes it is to the refraction of the visual zone that attention should be paid, the refraction in the other parts of the pupil being of little practical importance. On account of the small size of the visual zone in many eyes it is best to apply skiascopy from a distance of less than 1 meter from the patient's eye.

When the visual zone of the pupil differs materially in refraction from the part of the pupil that surrounds it, the eye is said to present *aberration*. This is called *positive* when the center of the pupil is more hyperopic or less myopic, and *negative* when the opposite is the case. When the aberration is high, on examining it from near the point of reversal of the margin of the pupil, the movement of the light will be swift at the margin and slow in the center, making it look as if the light in the pupil were wheeling around a fixed point at the center. This appearance is marked in conical cornea. Aberration of moderate degree causes the appearance of a ring of light at the margin of the pupil, which has a very distinct movement when the point of reversal for the center of the pupil has been reached.

**The Concave Mirror.**—With the concave mirror the movement in the pupil is reversed (see page 133); and one cannot vary much the distance of the mirror from the patient's eye, but must keep a fixed distance (usually somewhat less

than 1 meter), and bring the reversal to this point by changing the lenses used before the eye.

**The Use of Mydriatics.**—In addition to the local medicinal value of the mydriatics in the treatment of diseases of the eye—*e. g.*, iritis—these drugs are employed as aids of an accurate determination of ametropia. With the ophthalmometer, without the aid of mydriatics, and with the method of skiascopy, in the absence of prolonged mydriasis, good results are obtained; but it is a safe rule in all cases of suitable age, and in the absence of contraindicating symptoms, to employ an active mydriatic before attempting to select correcting lenses. This remark applies particularly to cases of astigmatism. The mydriatic accomplishes three purposes:

1. It dilates the pupil, and permits a thorough exploration of the interior of the eye, as well as a more perfect examination of the lens and vitreous humor than could be obtained without its aid. The student should not, of course, think it necessary to dilate the pupil of each eye which he subjects to an ophthalmoscopic examination; but glasses should never be adjusted without a thorough knowledge on the part of the examiner of all the details of the eye-ground and the transparent media.

2. It paralyzes the action of the ciliary muscle and places the accommodation in abeyance, rendering manifest types of ametropia which otherwise would remain latent.

3. It fulfils the important function of giving, during the time of its action, physiologic rest to the eye that is under its influence, and consequently helps to subdue any retino-choroidal disturbance or other congestive condition that pre-existing eye-strain may have originated. No matter how nearly perfect the correction of an optical error may be, if the coats of the eye are not in a healthy condition, or have not received a tendency to reach such a state, the correcting lenses will not be comfortable.

In practice, various mydriatic drugs are employed, the most common being the sulphates of atropin, hyoscyamin, hyoscin, and duboisin, and the hydrobromate of homatropin and scopolamin.

(a) *Atropin*.—Atropin is usually employed in a strength of four grains to the ounce. A drop of such a solution dilates the pupil in about fifteen minutes, and a very few moments later begins to paralyze the accommodation, which sustains a full paralysis in about two hours. The effect of atropin upon the accommodation remains for a week, but if, as is commonly the case, the drug is used for several days at a time, this influence is much prolonged, and full return to the previous power of accommodation is not secured for about twelve or fourteen days.

In using atropin for the purpose\* of correcting errors of refraction, a solution of the strength given above should be instilled into the eye, one drop at a time, three times for at least a day, preparatory to the determination, and in young subjects possessing hyperopic eyes, with active ciliary muscles, especially if there is associated spasm of accommodation, the drug must be continued for several days, or even longer, before the desired result is reached.

(b) *Hyoscyamin* is usually employed in the strength of two grains to the ounce, in the same manner. It produces wide dilatation of the pupil and complete ciliary paralysis, the effect of which is from six to seven days in duration. Many surgeons prefer this drug to atropin, and believe that its effects are equally good, while it enjoys the advantage of a much more temporary action upon the function of the ciliary muscle. The salt must be neutral, and the solution filtered through neutral paper (Risley).

(c) *Hyoscin* and *duboisin* in similar strength have similar actions, the latter drug being even more transitory than hyoscyamin in its effect, return to accommodative power occurring in from four to five days. Both of them have the disadvantage of producing marked constitutional disturbances, at times rendering their employment disadvantageous.

(d) *Homatropin* is a drug which produces a very transitory effect upon the ciliary muscle, full return of accommodation occurring in about fifty hours after the last instillation.

To use this drug properly, it must be employed by cumulative instillations in the strength of eight to sixteen grains to



the ounce, one drop of such solution being used every ten or fifteen minutes for an hour and a half preceding the determination, and then waiting forty minutes. At the end of this time the maximum effect of the drug upon the accommodation is secured. In the opinion of some surgeons this drug is an insufficient paralyzer of accommodation, but if caution in regard to the cumulative instillations is observed, and the rule given above carefully followed, very satisfactory results may be obtained. Its influence may be neutralized by eserine.

*Scopolamin*, introduced by Raehlmann, may be employed in the strength of two grains to the ounce. Two instillations of one drop each forty-five minutes apart are sufficient. Mydriasis begins in twelve, and is complete in thirty, minutes; cycloplegia occurs in about forty-five minutes. Full return of accommodation may be expected in from five to six days. Toxic symptoms—staggering, vertigo, and dryness of the throat—may develop. Scopolamin is said to be more valuable than atropin in inflammatory affections of the eye, and not to increase intra-ocular tension (Raehlmann).

It is not safe to use strong mydriatics in elderly people, and they must never be employed if there is any symptom of glaucoma. It is unnecessary to use them when that age has been reached after which the accommodation is so weakened that hyperopia ceases to be latent; indeed, it is rarely necessary to employ them after the forty-fifth year.

*Euphthalmin* is an active mydriatic in a 5 to 10 per cent. solution. It produces maximum dilatation of the pupil in about fifteen or twenty minutes, and the pupil returns to its normal size in five to six hours. Its influence on accommodation is relatively slight, therefore it has no practical value as a cycloplegic. It is an admirable agent for producing brief dilatation of the pupil, and, fortunately, produces no perceptible effect upon the cornea. It may be combined with cocaine, 1 per cent. of each, and its mydriatic efficiency thereby enhanced.

*Hydrochlorate of cocaine*, in addition to its anesthetic action, is, in 2 to 4 per cent. solution, an excellent mydriatic, but its effect upon the accommodation is so slight that it is valueless

for the purpose of preparing an eye for the estimation of any error of refraction.

Other mydriatic drugs which may be mentioned are *ephedrin homatropin*, 1 : 10 (Groenouw); *mydrol*, 10 per cent., and *atrosin*. The last-named drug is somewhat similar to scopolamin in its action.

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**ERROR.**

Page 142, line 11, should read: "two grains to the ounce"—not "grams."

## CHAPTER IV.

### NORMAL AND ABNORMAL REFRACTION.

THE cornea, aqueous humor, crystalline lens, and vitreous body are the media by which rays of light passing into the eye are refracted and brought to a focus with the production of an image on the retina. Because the two surfaces of the cornea are practically parallel and the index of refraction of the cornea and the aqueous humor are the same, the *dioptric apparatus* may be reduced to the anterior surface of the cornea and the anterior and posterior surfaces of the crystalline lens. The cornea is the principal lens when the eye is at rest, and it has a higher refractive power than the crystalline lens; but during maximum accommodative effort the refractive power of the crystalline lens approaches that of the cornea. The formation of a distinct retinal image requires that the curvature of the corneal meridians shall be symmetric, that the plane of the lens shall be perpendicular to the visual line, that its sectors shall have a uniform density in corresponding layers, and that the focal length of the dioptric apparatus shall correspond with the length of the visual axis.

**Emmetropia.**—To the normal eye, which produces a distinct image of distant objects on the retina, without accommodative effort, the term *emmetropic* is applied, and the condition may be defined as follows:

*Emmetropia is that refractive condition of the eye in which the visual axis corresponds exactly with the focal length of the dioptric apparatus when at rest; the far point lies at infinity, and the eye, in its condition of minimum refraction, is adapted to focus parallel rays on the retina. The principal focus lies on the retina.*

The emmetropic eye has an average length of about 22

mm., although emmetropia is still possible with a longer or shorter axis, if the curvature of the ocular lenses varies in proportion. Emmetropia, as Edward Jackson tersely puts it, is the ideal state of refraction. Such an eye has a range of vision from infinity to its near point (see table, page 47). Glasses are not required for distant vision, neither are they needed for reading or close work until that age is reached when the accommodative power begins to decline—*i. e.*, about the forty-fifth year. No great departure from emmetropia can long exist without producing more or less disturbance of the function of vision and of the nutrition of the ocular tissues. To restore the eye, the refraction of which is abnormal, to a condition of emmetropia, or at least one approaching it, constitutes a most important part of the practice of ophthalmology. This will be more readily conceded when it is remembered that emmetropia is comparatively rare, occurring in not more than 1.5 to 2 per cent. of properly examined eyes.

**Ametropia.**—To the eye which fails in the requirements just described the term *ametropia* is applied, and the condition may be defined as follows:

*Ametropia is any departure from the normal optical condition—that is, from an exact correspondence between the visual axis and the focal length of the dioptric apparatus when at rest. The principal focus is not a point or does not lie on the retina.*

Ametropia is denominated *axial* when the length of the eyeball is increased or diminished, and *curvature* when, the axis remaining unchanged, the curvature of lenses of the eye undergoes variations. Ametropia presents itself under three conditions: (1) *Hypermetropia, hyperopia, far-sightedness, or oversightedness*; (2) *myopia, short-sightedness, or near-sightedness*; (3) *astigmatism*.

It is convenient to distinguish the first two classes of ametropia by the relative position of the principal focus to the retina.

**Hyperopia.**—*Hyperopia is that form of ametropia in which the retina is situated in front of the principal focus of the eye. The visual axis of the eye is shorter than the focal length of the dioptric apparatus when at rest.*

The far point of the eye is negative, and is represented by the point behind the eye to which rays must converge before entering the eye, in order to be united on the retina. The refractive apparatus of the hyperopic eye, in a condition of minimum refraction, is adapted to bring rays converging to this point to a focus on its retina. Rays passing out of a hyperopic eye have a divergence as if they came from this point.

**Causes and Varieties.**—The eyeball may be abnormally short, constituting *axial hyperopia*; a deficiency of 1 mm. in the length of the optic axis produces 3 diopters of hyperopia; or its refractive power may be deficient, *curvature-hyperopia*; an increase of 1 mm. in the length of the radius of curvature of the cornea produces a hyperopia of 6 diopters; or the crystalline lens may be absent, *aphakial hyperopia*.

Hyperopia is further divided into: (1) *Manifest*; (2) *latent*; (3) *total*. Manifest hyperopia (H. m.) is represented by the strongest convex lens through which an eye with perfectly intact accommodative power retains distinct distant vision; latent hyperopia (H. l.) is the amount in excess of the manifest which can be developed by the use of a cycloplegic—for example, atropin; total hyperopia (H. t.) is the sum of the manifest and the latent—that is, the entire amount of the hyperopia which is developed after paralysis of accommodation or complete relaxation of the ciliary muscle. Evidently latent hyperopia is the difference between the manifest and the total. Manifest hyperopia is either *facultative* or *absolute*—facultative when it can be overcome by an effort of accommodation, absolute when it cannot be overcome by an effort of accommodation.

Hyperopia is nearly always *congenital*, and is often *hereditary*, especially its high grades. In some senses it may be regarded as due to an imperfect development of the eyeball, which, however, may increase its length with the growth of the rest of the body, and this refractive condition may diminish, pass into emmetropia, or, more rarely, into myopia. An apparent increase of hyperopia due to failure of accommodation caused by advancing years is often seen—that is, latent hyperopia becomes

manifest. A real tendency to slow increase of hyperopia is due to gradual increase of the size of the crystalline lens (Jackson). In early life none of the existing hyperopia is absolute unless it is of high degree; after fifty-five practically all of it becomes absolute.

**Symptoms.**—Hyperopia renders it difficult to maintain a distinct image of small objects—*e. g.*, printed matter—for prolonged periods of time. If the effort is persisted in, the accommodation becomes exhausted, aching of the eyes and head—in short, *cyc-strain*—appears, and finally the work must be discontinued (*accommodative asthenopia*). Sudden failure of accommodation, with consequent blurring of vision, is frequent, and often first appears if the patient has been weakened by illness. Hyperopes often place a book or small objects in a strong light in order to contract the pupil and thus render vision clearer.

Hyperopia frequently gives rise to *spasm of the accommodation*, owing to the persistent contraction of the ciliary muscle necessary to overcome this error of refraction, and then simulates myopia, distant vision becoming indistinct. Under these circumstances concave lenses may improve vision, and, in ignorance of the true state of affairs, are sometimes prescribed, much to the detriment of the patient. A mydriatic will reveal the real condition of the refraction. Spasm is prone to occur in individuals of neurasthenic condition; it bears no relation to the vigor of the accommodation. The reverse is often true—that persons of relatively feeble accommodation have a marked cramp of the ciliary muscle. Spasm of accommodation is not, however, limited to hyperopia.

*Convergent strabismus* is often the earliest symptom of hyperopia in childhood; it arises in connection with efforts of accommodation. When the hyperopia is too great to be managed by the accommodation, the affected children frequently hold their books close to their eyes, and, by contracting the palpebral fissures, are enabled to see better than with the book at a greater distance, because the object is seen under a larger visual angle, and the narrow slit between the lids cuts off the more divergent rays. These children are often erroneously

supposed to be near-sighted, and concave glasses are given to them, which increase, instead of mitigating, the trouble.

As a result of hyperopia the coats of the eye become inflamed. Conjunctivitis, blepharitis, and congestion of the retina and choroid are very frequent complications. *Persistent headache*, aggravated by using the eyes, various nervous symptoms, reflex in their nature, as well as disturbances in the visual function, are the common results of hyperopia (see also page 170).

**Determination of Hyperopia.**—Hyperopia always exists: When distant vision is improved by a convex glass; when the patient can read fine print through a convex glass at a greater distance than its focal length; when with the ophthalmoscope the interior of the eye, otherwise normal, is seen distinctly with

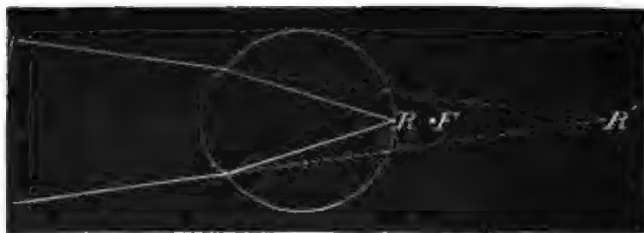


FIG. 57.—Far point of a hyperopic eye. Rays from  $R$  on the retina of the hyperopic eye after refraction diverge; these rays, prolonged backward, would unite at the point  $R'$ .  $R'$  is the far point.

a convex lens; usually when the near point lies at a greater distance from the eye than is proper for the age; and when the phenomena described in connection with the shadow-test on page 136 are present. To ascertain the presence of latent hyperopia a mydriatic should be employed. Its use is imperative in the presence of spasm of accommodation. The ciliary muscle is fully developed in hyperopic eyes, especially the circular fibers, which may be overdeveloped.

**Correction of Hyperopia.**—The principal focus,  $F$ , of the hyperopic eye lies behind the retina. Consequently the retina  $R$  is situated within the principal focus, and its conjugate focus or far point  $R'$  is virtual (Fig. 57). Rays from  $R$  seem, after refraction by the eye, to have come from  $R'$ ; conversely rays

converging to  $R'$ , after refraction by the eye, unite in  $R$  on the retina. The rays which come from the retina,  $R$ , of such an eye, after emerging from the eye are divergent, and, prolonged backward, would unite in the point  $R'$ . The distance of this point from the cornea is the focal length of the glass which corrects the hyperopia. The amount of divergence of the emergent rays is dependent on the degree of the hyperopia—that is, the distance  $R$  lies in front of  $F$ . The higher the degree of hyperopia is, the farther  $R$  lies in front of  $F$ , and the nearer the point of divergence  $R'$  lies to  $R$ ; conversely, the lower the degree of hyperopia is, the nearer the point  $R$  lies to  $F$ , and the farther back the point  $R'$  lies. The distance of  $R'$  must be less than infinity; otherwise, the eye would be emmetropic.

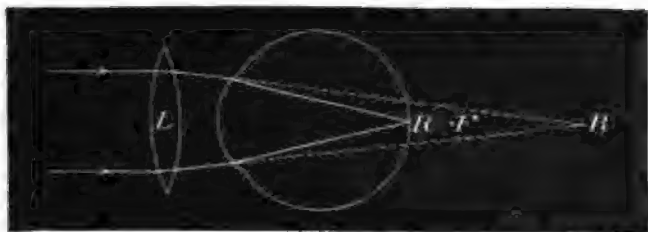


FIG. 58.—Correction of hyperopia by a convex glass. The lens  $L$  gives to parallel rays a convergence toward the point  $R'$ ; they will consequently be united on the retina  $R$ .  $R'$  is the virtual conjugate focus of  $R$ .

If parallel rays are given a convergence to the point  $R'$  by a convex lens placed before the eye, the rays will come to a focus at the point  $R$  on the retina, since the path of the rays passing into the eye after refraction by a convex lens (Fig. 58) is exactly the same as that of the rays diverging from the retina and passing outward (Fig. 57), only the direction is reversed. The far point  $R'$  of the hyperopic eye is the point to which parallel rays must be given a convergence by a convex lens in order to come to a focus on the retina. The amount of this necessary convergence represents the deficiency between the refraction of the hyperopic and that of the emmetropic eye; the degree of hyperopia is, therefore, in an inverse ratio to the distance of  $R'$ .



To correct hyperopia the refraction of the eye must be increased by a convex lens of sufficient strength to bring  $F$  on the retina. This glass corrects the hyperopia by shortening the focal length of the dioptric apparatus to correspond exactly with the length of the visual axis. The far point  $R'$  is removed to infinity. Parallel rays come to a focus on the retina without any effort of accommodation, and rays emerging from the eye are rendered parallel.

In order to neutralize the hyperopia that convex glass must be selected which gives the greatest visual acuity. As the greatest visual acuity is obtained when the retinal image is sharply formed, and as this occurs when rays are brought to an exact focus on the layer of rods and cones, the maximum visual acuity is the most satisfactory evidence that rays are exactly focused on the retina. If these rays are parallel, the glass which brings them to a focus on the retina corrects the hyperopia. Rays from objects at 6 meters' distance are sufficiently parallel for this purpose.

**Correction of Hyperopia with Test-types and Trial-lenses.**

—The card of test-letters, in good illumination,—either artificial light or ample daylight,—is hung on a wall, at 4 to 6 meters from the patient. A pair of trial-frames is placed before the patient's eyes and one eye at a time examined, the other being screened by an opaque disc. The patient is supposed to have his accommodation paralyzed by a mydriatic, or to be beyond forty-five years of age. He is required to read the smallest letters which he can see distinctly on the card. The resulting sharpness of vision is noted. A convex glass is now placed before the eye. If this glass improves vision, but does not raise it to normal, stronger lenses are tried until the one is obtained which yields the maximum visual acuity; or, if the stronger glasses do not improve the vision, successively weaker ones are tried until that glass is found which gives the greatest sharpness of sight. This is the lens which corrects the hyperopia. If the acuity of vision is raised to normal by a convex spheric lens, it is not likely that astigmatism is present, but every case should be examined with a view to discover any

astigmatism. If none exists, the convex glass is all that is required to correct the ametropia.

In the absence of a mydriatic and the presence of some accommodative spasm, vision being equal in the two eyes, a more suitable glass may often be obtained by testing both eyes simultaneously, because with parallel axes the accommodation is more likely to undergo relaxation. This effect may be further increased by placing a prism of  $2^\circ$  or  $3^\circ$  (centrads) before one eye, with its base inward. The effect of this is to relax the internal recti muscles, and indirectly the accommodation. It is a good plan to begin by placing before the eyes a lens of stronger refraction than the one required, and gradually weakening it by concave glasses of successively higher numbers until normal vision is reached. The glass required is then the difference between the two.

The proof that the glass selected is the correct one depends upon the ability of the patient to focus parallel rays on the retina. Parallel rays may be obtained by placing an object at the principal focal distance of a convex lens. The principal focal distance of a 4 D lens is 25 cm. Therefore if the glass corrects the hyperopia, the patient should be able to read fine print at 25 cm. distance with + 4 D added to his correction. If he reads at a greater distance than 25 cm., some hyperopia is still uncorrected. If he reads at a shorter distance than 25 cm., the hyperopia is probably overcorrected.

The degree of hyperopia may also be determined by placing a convex lens before an eye the accommodation of which is paralyzed, and by finding the distance at which small type appears most distinct. Suppose the lens selected is 4 D (focal distance = 25 cm.), and that the patient reads best at 33 cm. Now 33 cm. is farther than the principal focus, and the rays therefore are convergent after passing through the lens, since a 3 D lens would render them parallel;  $4\text{ D} = 3 + 1$  would give them a convergence of 1 D to the conjugate focus, 1 meter back of the eye; 1 D therefore represents the amount of the hyperopia (see page 148).

*Rule.*—Subtract from the lens employed the lens whose focal

distance equals the distance at which the patient reads. The difference is the degree of hyperopia.

**Correction of Hyperopia with the Ophthalmoscope and Shadow-test.**—To correct hyperopia in children before they are old enough to read, the ophthalmoscope and skiascopy are the means upon which reliance is placed, but these methods should also be employed in adults. They are explained on pages 122 and 132.

**Ordering of Glasses.**—After the degree of the hyperopia has been determined, the very important question presents itself, What glass shall be ordered? While the eye is under the influence of the cycloplegic, distant vision is distinct with the full correction; after the effects of the drug have disappeared, it is often dim with the full correction, and a haze seems to lie over all distant objects, which disappears when the glasses are removed. On the other hand, the headache, asthenopia, and congestive troubles return if the hyperopia remains uncorrected. Spasm of accommodation is the disturbing factor in this problem, and it is so variable in different individuals that no precise rule can be given. Many persons wear a full correction with comfort, and do not need any modification; others will tolerate only a small part of the full correcting glass.

There are two methods of dealing with this difficulty: first, to order full correction while the eye is still under the influence of the mydriatic, and to insist that this shall be worn constantly during the time that the accommodation is returning to its normal state. If distant vision remains dim, after full accommodative power has returned, the glasses may be weakened sufficiently to secure normal acuity of sight for long ranges. The instillation of a weak solution of eserine (gr.  $\frac{1}{40}$ –f $\frac{3}{j}$ ) will sometimes assist in soothing the irritability of the ciliary muscle.

It should be borne in mind, as Jackson insists, that the glass which gives the best correction at 4 or 6 meters is not the correcting glass for the total H, but in reality is an overcorrection of  $\frac{1}{4}$  to  $\frac{1}{8}$  D. Strictly speaking, rays coming from these distances are not parallel, and the glass which focuses them perfectly on the retina will not perfectly focus parallel rays. Hence,

in ordering a full correction, the glass which gives the best vision at 4 or 6 meters must be weakened by  $\frac{1}{4}$  or  $\frac{1}{6}$  D. If this fact were more often remembered, less difficulty would be experienced in inducing patients to wear a full correction.

Second, the eyes are first allowed to regain their full power of accommodation before the final glass is prescribed, and this is the plan which should be pursued. If vision is normal with the full strength of the glass, it may be ordered; if not, it should be reduced to that number with which full visual acuity is obtained. This may be only one-half, one-fourth, or even less, of the full amount. It is necessary in these cases to increase the strength of the glass from time to time as symptoms of fatigue manifest themselves. When the glass ordered for distance is only a small part of the full correction, it is very often necessary to order another pair of lenses for reading which embodies nearly or quite the full amount of correction.

A frequent cause of inability to wear a full correction depends upon the development of convergence insufficiency, causing an associated action of accommodation with the muscular effort necessary to bring the visual axes into a parallel condition (see page 610).

Some surgeons, instead of ordering the glass nearest in strength to the full correction, with which the patient still has normal visual acuity, in each case systematically weaken the lens which neutralizes the total hyperopia by a given amount, usually 0.75 D. Donders advised a glass based upon the manifest H, to which one-quarter of the latent H was added. Macnamara recommends, in absolute hyperopia, the use of a convex glass, the strength of which shall be equal to one-half of the sum of the manifest and total hyperopia—*e. g.*, manifest H = 1.5 D; total H = 3.5 D. H. m. + H. t. = 5 D; ordered + 2.5 D. The author, if convergence is ample, usually orders the full correction of H less 0.25 D. If there is exophoria, this plan must be modified, or the defect remedied by prisms or by prismatic exercises. The indistinct vision, caused by full correction of H, due to a disturbance of the relative range of accommodation and convergence, may be overcome by

systematically training the convergence (see page 614). Whether a glass shall be worn constantly or not depends upon the symptoms which the hyperopia has produced and the character of the patient's work. Frequently hyperopes are entirely comfortable if reading-glasses alone are used. Finally, glasses need not be ordered simply because hyperopia exists; but only when it gives rise to the symptoms which have been described. Thus one person may easily manage one or more diopters of H without glasses; another may have all manner of asthenopic and reflex nervous symptoms produced by 1 D of H or even less.

The visual line is often very much displaced to the inner



FIG. 59.—Angle gamma in hyperopia. *O A*, The optic axis; *N*, the nodal point of lens; *V M*, the visual line, cuts the cornea at inner side of optic axis; *O N V*, the angle gamma, in this case is positive; *M*, the macula.

side of the cornea in hyperopia, causing a very large value of the angle gamma.

**Myopia.**—*Myopia is that form of ametropia in which the retina is situated behind the principal focus of the eye, and only those rays which diverge from some point nearer than infinity can come to a focus on the retina. This point is the far point of the myopic eye.*

The far point, therefore, is limited by the amount of divergence necessary to bring the focus of the rays on the retina. The higher the degree of myopia is, the closer will the far point *r* lie to the eye. Rays coming from the retina converge to the far point and form there an image (Fig. 60). This image can be seen by the ophthalmoscope. The far point and the retina are conjugate foci (see page 134).

**Cause and Varieties.**—Myopia may be produced by in-

creased refraction of the cornea or crystalline lens, *curvature-myopia*, or by too great a length of the optic axis, *axial myopia*. In the great majority of cases myopia is due to elongation of the optic axis, often the result of pathologic changes in the coats of the eye.

Myopia may also be occasioned by changes in the shape of the cornea as a result of disease—for example, conical cornea. Myopia, unlike hyperopia, is rarely congenital. It usually makes its appearance from the eighth to the tenth year, and tends to be progressive, especially during the early school years. Sometimes it is the continuation of a process started in hyperopic eyes, especially in those with astigmatism, and the gradual transition from hyperopia to myopia is not infre-

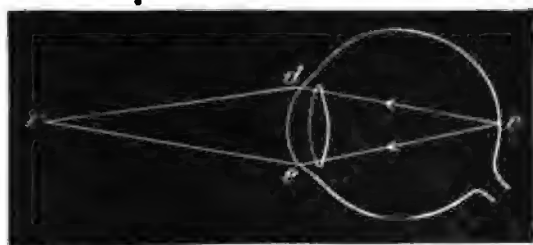


FIG. 60.—Far point of a myopic eye. Rays diverging from the retina  $c$  will, after refraction, converge to  $r$ ; conversely, rays diverging from  $r$  will, after refraction, converge to  $c$ ;  $r$  is the far point;  $r$  and  $c$  are also conjugate foci.

quently seen among patients who return for examination. According to Risley, there may be an arrest of the increase of myopia as the result of treatment and the optical correction of ametropia.

Myopia is more prevalent in some countries than in others, and is especially frequent in Germany, in the higher classes of the schools, reaching, according to Cohn, 60 per cent. Myopia is said to be more common among Jews than among Christians of the same social class (Sydney Stephenson). Although the largest number of myopes is found among the upper classes,—that is, among those upon whom the demands of modern civilization fall most heavily, and among artisans whose work demands close inspection,—high grades of this

refractive defect may also be found among those who do not use their eyes for close work, and occasionally among children who have not yet been subjected to the influence of school life.

Myopia is frequently hereditary, and may occur in several members of one family.

An acute posterior scleriticochoroiditis may occasion myopia in any eye. Alteration of the refractive power of the lens as the result of beginning cataract may cause myopia, the so-called *second sight* (see page 431). and, according to Hirschberg, the late development of myopia—that is, after the fortieth year, unassociated with cataract formation—is not an uncommon sign of diabetes. The author has seen several such cases.

In normal eyes the sclera does not yield to the intra-ocular pressure, but if from any cause its resisting power is reduced, distention takes place and the anteroposterior axis of the eyeball is elongated. Among the causes which have been invoked to explain the elongation of this axis of the eye—*i. e.*, the production of myopia—are the following: The incentive given by the shape and size of the orbit to greater development of the eyeball; the compression of the eyeball by the external muscles, causing distention of its coats backward on account of the excessive convergence rendered necessary by the close range at which myopes are obliged to work;<sup>1</sup> the strain of accommodation; racial peculiarities; inflammatory changes within the eye—for example, scleriticochoroiditis, induced by habits of life which promote fulness of the veins of the head and neck and hinder the egress of the blood from the eye or are set up by eye-strain itself induced by

<sup>1</sup> Compression of the eyeball under these circumstances may be caused by the external rectus. According to Stilling, however, the superior oblique is the principal compressing muscle in myopia, the low position of the trochlea increasing the amount of force which this muscle exercises on the globe. This position occurs because there is, according to this author, a diminished vertical diameter of the orbits in myopes, and therefore he believes he can detect those children who will become myopic. Schmidt-Rimpler, however, rejects Stilling's conclusions and states that the vertical diameter of the orbit is higher in myopia than in hyperopia.

excessive study, bad ocular hygiene, imperfect illumination, etc.; and an inherited tendency, the commencement and increase of the myopia being caused by general and local vascular congestion, which are the result of constitutional disturbance—for example, cardiovascular disease (Batten).

Although prolonged use of the eyes at near work necessitating excessive convergence explains the acquisition of myopia in many cases, only a portion of those subjected to such a strain become myopic. Therefore in this number, as Fuchs remarks, special additional factors must be present: predisposition, too great approximation of the work, and improper ocular and general hygiene, exophoria, and spasm of accommodation.

Among other causes of less significance may be mentioned an unusually great distance between the pupils, rendering convergence more difficult, a divergent squint, and a large size of the angle gamma (in this case negative), demanding more strain on the part of the eye muscles in the efforts of convergence. After myopia is once produced the eyeball, by its oval shape and greater size, may act as a cause of the further development of this refractive defect by reason of the increased muscular effort which is required to rotate such a globe inward during convergence, and the compressing effect of the external recti muscles on the increased posterior segment of the eyeball.

At first probably all cases of myopia are *progressive*, but many are checked because the eyes are removed from the strain of close work or are placed under better hygienic surroundings. Other cases may progress until the increased effort of convergence demanded by the increased myopia becomes too difficult to sustain, one eye deviates outward and there is produced a *divergent strabismus*. Then further increase of myopia may stop, or the inflammatory changes already set up within the eye may continue, the distention of the ocular coats increases, and the most serious organic lesions arise; in other words, there is *malignant* or *pernicious myopia*.

**Symptoms.**—The symptoms of myopia naturally range themselves under the two classes, subjective and objective.



The *subjective symptoms* are those which arise because the range of vision is limited by a radius of a few centimeters. Distant objects are not clearly perceived by the myopic patient, because as soon as an object passes beyond his far point it becomes indistinct.

Myopes have an inclination to avoid outdoor sports on account of their poor vision, and exhibit a greater fondness for occupations which come within their range—*c. g.*, reading, drawing, etc.—than for others which require good distant vision. The prolonged congestion of the eyes which such habits entail tends to increase the myopia. Headache and reflex phenomena are unusual accompaniments of myopia unless complicated with astigmatism, which is a factor in the further increase of the refraction. Myopia, however, frequently causes aching of the eyeballs, very imperfect ocular endurance, congestion of the conjunctiva—indeed, many of the symptoms which are strictly asthenopic, especially when the choroid is undergoing the changes which are determining the increase in the refractive power.

The *objective symptoms* of high myopia may embrace: (1) A notably prominent and elongated eyeball, with a large and somewhat sluggish pupil; (2) a rather stupid expression of the countenance from inability to note the expression in the face of others; (3) a peculiar manner of reading—the book is held stationary and the face is moved from side to side, following each line; (4) certain characteristic ophthalmoscopic appearances. With the direct method the optic disc appears enlarged; at its outer side there often is a crescentic area of whitish hue, depending upon alterations in the choroid, known as a *conus* or *myopic crescent*. This area may begin next to the disc with a space of complete atrophy, succeeded by a rim of partial atrophy and pigment disturbance, which in its turns merges into a patch of choroidal congestion. Sometimes the entire disc is surrounded by areas of choroidal disturbance, and the general choroid may exhibit many alterations depending on congestion, edema, rarefaction, atrophy, and pigment accumulation (see also page 160 and Fig. 62). Weiss and B. Alex. Randall have described a curvilinear reflex, generally at

the nasal side of the disc, as a prodromal sign of myopia; (5) divergent squint. The squinting eye is often amblyopic. Binocular vision does not exist in such a case; the good eye, freed from the necessity of convergence, reads at the far point without any effort, and glasses for reading are sometimes unsatisfactory because the print appears smaller on account of its removal to a distance greater than the far point of the eye.

The visual axis in myopia sometimes passes through the cornea at the outer side of the optic axis; the *angle gamma* is then *negative*, and the eye in looking at a distant object turns inward in order to bring the visual line to fix on it, giving rise to an apparent convergent squint (Fig. 61). This renders necessary a greater degree of convergence.

Myopic eyes are popularly considered as strong eyes,

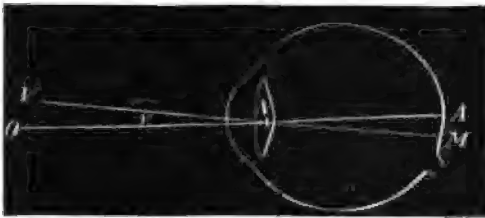


FIG. 61.—Angle gamma in myopia which is negative.

because they see fine print at close ranges. This is true only in those cases in which the tunics of the eye have suffered no injury—where, for example, the myopia is of moderate degree and not due to disease.

Myopia does not usually decrease with age, but, on the contrary, tends to increase up to adult life or later.

Very high degrees of myopia (*malignant* or *pernicious myopia*) are marked by ravages in the structure of the choroid and retina. The pigment-cells wander off in some places and accumulate in others, producing marked contrasts in the appearance of the eye-ground. Large areas of atrophy, glistening white in color, alternate with black splotches, and at times hemorrhages occur. The macular region is especially prone to degenerative, atrophic, and hemorrhagic changes. The disc is often surrounded by an atrophic area, the *posterior staphyloma*,

which represents an area of thinned and distended sclera. The vitreous humor is semifluid, and floating opacities are often visible, sometimes being so large as to obscure vision. Owing to the intimate relation between retinal nutrition and the pigmented epithelium of the retina, the loss of the latter is followed by diminution in the visual acuity. In higher grades of myopia—15 to 20 D, and sometimes still higher—the condition of the eye is very desperate, and the morbid processes

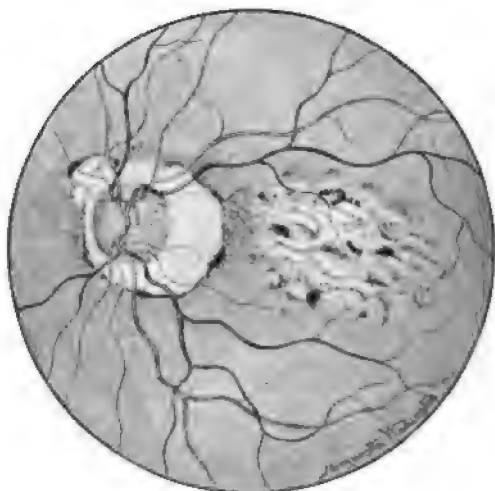


FIG. 62.—Eye-ground in progressive myopia. Large posterior staphyloma surrounding the nerve-head. Macular region occupied by an area of semi-atrophic retinochoroiditis.

may culminate in detachment of the retina and complete blindness (see also page 158).

The ciliary body is feebly developed in myopia of considerable degree, as a result of which accommodation is often much diminished, and the anterior chamber is deep. For this reason the tendency to glaucoma in myopic eyes is said to be lessened.

**Determination and Correction of Myopia.**—Myopia may be determined: (1) By the position of the *punctum proximum* of accommodation, which is closer to the eye than is normal for

the age; (2) by the position of the farthest point of distinct vision obtained by test-types; (3) by the ophthalmoscope and retinoscope (page 135); (4) by the concave glass which gives distinct vision at a distance of 4 to 6 meters.

Only those rays which diverge from a distance not greater than the far point can be focused on the retina of the myopic eye. In order that it shall see at any greater distance than this the rays must be given a divergence as great as if they came from this point (Fig. 63). If the greatest distance at which a myopic eye can see fine print is 14 cm., in order to see at a still greater distance the eye would require a concave glass which would give rays a divergence as if they came from this point. By dividing 100 by 14 we obtain the number of diopters (7) necessary to produce this divergence. As the far



FIG. 63.—Manner in which concave lens causes rays to diverge from the far point of a myopic eye.

point is measured from the cornea, the glass must be placed close to the cornea; if the glass is removed 1 cm. from the cornea, it is plain that its focal point will also be 1 cm. farther away; therefore it is necessary to employ a glass of shorter focus.

*Example.*—Suppose it is desired to cause the rays to diverge from a point 14 cm. in front of the cornea, and the glass is to be placed at 1.5 cm. in front of the cornea; it is evident, under these circumstances, that the glass would require to have a focus of  $14 - 1.50 = 12.5$  cm., or

$$\frac{100}{12.5} = 8 \text{ diopters.}$$

The usual position for a glass is about 13 mm. in front of the cornea.

In low degrees of myopia this does not affect appreciably the strength of the glass, but in the higher degrees it makes

a serious difference. The concave glass is therefore somewhat stronger than the actual myopia, especially in the higher grades.

The degree of myopia may be determined approximately by this method more rapidly than by beginning the trial at 6 meters with glasses (in this instance, concave) in the manner already described in connection with hyperopia (page 150). One example will suffice:

A patient reads fine print distinctly at 8 cm. from the cornea, but not at a greater distance, the eye being under the influence of a cycloplegic; this is its far point. In order that the patient may see at an infinite distance, parallel rays must be given a divergence as if they came from 8 cm. in front of the cornea. As the glass will be placed 13 mm. in front of the cornea, its focal length must be 8 cm. - 1.3 cm. = 6.7 cm., or 67 mm.  $\frac{1000}{67}$  mm. equals 15 D, as the number of the concave lens required to permit distant vision. A lens of this number should be placed in the trial-frame, and the vision determined through it by means of test-types at the usual distance. Perhaps a weaker or a stronger lens may give better vision, and hence several numbers should be tried in succession, until that glass is selected with which the greatest acuity of vision is attained, and which then represents the correcting lens.

A patient often will select a glass of higher number than the one really required, because the letters have a blacker and sharper appearance when seen through concave lenses; but unless the stronger glass at the same time secures for the patient an increased acuity of vision it should be rejected, and the weaker lens adopted. If several lenses give equally good vision, the weakest one should be chosen.

The method of determining the correcting lens in myopia by means of ophthalmoscopy and skiascopy is elsewhere described (see pages 121 and 132).

**Treatment of Myopia.**—This should include *prophylactic measures* and the selection of suitable concave glasses. From the eighth to the eighteenth year—that is, during school life—myopia specially tends to appear and to progress; hence prophylactic means are urgently required during this period. No child should be permitted to begin school duties until the exact state of the refraction has been determined, and if vision

is deficient and eye-strain likely to develop, suitable lenses should be prescribed. Strict attention should be paid to the following conditions: A correct position of the head and body during study, secured by means of a suitable desk, the surface of which is so tilted that the page of the book lying on it is parallel to the scholar's face, and by a chair or stool of proper height both in relation to the desk and the floor; the employment of books with sufficiently large and distinctly printed type; good illumination coming from behind the scholar and preferably over the left shoulder; proper ventilation; restriction of the hours of study within reasonable limits, and plenty of outdoor exercise. These precautions apply with equal force to hours of study at home.

As Priestley Smith has well said, it is necessary "to suspect every myopia, and especially every youthful myopia, of a tendency to increase, until time has proved it to be stationary; to be doubly suspicious in the presence of congestion or atrophy of the eye-ground; and to reëxamine at intervals of six months, twelve months, or longer, according to the nature of the case." These examinations should be made with the help of mydriasis—if possible, with atropin.

If a tendency to divergence exists in early life, it is sometimes proper to remove this by tenotomy of the external rectus as a preventive measure against the development of myopia.

Since Fukala's recommendation removal of the crystalline lens (discission, followed by extraction, or *phakolysis*) has been practised by a number of operators for the relief of high myopia (15 D or more). Improvement in vision and increase in the distance at which eyes can be used in near work are the results of successful operations, which, according to von Hippel, may not reach their best standard until a year after the operation—checking of the increase of the myopia.

The chief dangers of the operation are: Intra-ocular hemorrhage, detachment of the retina, secondary glaucoma from swelling of the lens, iritis, and infection of the corneal wound. The chief contraindications are: Extensive degeneration of the choroid, retina, or vitreous, diminished intra-ocular tension, a tendency to intra-ocular hemorrhage, previous loss of one

eye from any cause, and advanced age. As C. S. Bull puts them, the chief indications for the operation are: If the best possible correction with glasses does not give the patient sufficient vision for his needs or social position, and if there is a true progressive myopia which is already above 12 D. The author's experience with the operation has been very limited, but it has been favorable. To compute the probable correcting glass after loss of the crystalline lens, according to Landolt, one should divide by 2 the number of diopters of the correcting glass of the complete eye, and when concave, subtract it from 11 D, and when convex, add it to 11 D.

**Ordering of Glasses.**—After the estimation of the degree of myopia, astigmatism having been excluded, or, if present, corrected, the strength of the glass suitable for constant use, reading, or other special work must be determined. This is decided by the visual acuity, the range of accommodation, the degree of the myopia, and the condition of the external ocular muscles.

Young people (under twenty) with good vision and a moderate degree of myopia (under 5 D) should wear the full correction constantly if the accommodation is ample and no signs of fatigue are evident.

Indeed, full correction is the object to be attained for young persons with normal visual acuity and binocular near vision, no matter how high their myopia (Jackson), provided the lens selected shall not be an overcorrection when brought close to the eye. When visual acuity is imperfect or binocular vision lost, it is better to order a partial correction for near work. When wearing a partial correction the patient is tempted to improve distant vision by looking obliquely through the glass. But this gives it a cylindric effect, varying with the direction of the visual axis, and is always injurious.

Still, in high grades of myopia associated with lowered vision it is often necessary to diminish the full correction from 1 to 3 D. It is evident that the greater the visual acuity, the farther away the same size of type can be seen; hence the demand on accommodation is less as the visual acuity is greater.

When strong concave lenses are first worn, a lack of accom-

modation often appears, which is restored by a few months' use of the glasses. For the relief of this deficiency it is advisable to give a partial correction for near work until ample power of accommodation is gained, when the full correction may be used for all purposes.

As age advances an additional glass should be ordered for reading which will give the patient a far point of from 30 to 60 cm. In order to obtain this, the full correction must be diminished from 1.50 to 3 D.

The *position* of the lens used to correct high grades of myopia is of great importance. The nearer the lens is placed to the cornea, the stronger it becomes; conversely, the farther it is removed from the cornea, the weaker it is. The strong concave lenses necessary to correct high degrees of myopia in this way may sometimes be utilized by the patient to gain artificial accommodation. By bringing them close to the eye vision is adapted for distance; by pushing them from the eye, divergence is lessened and the eye is adapted for a closer point.

The visual acuity in high myopia is usually reduced, and in those cases accompanied by changes in the retina and choroid this reduction assumes a considerable grade. Sometimes very slight improvement in distant vision is secured by concave glasses, and near vision may not be at all benefited. Under these circumstances patients see better by using one eye alone and bringing the print or other work close to the eye, because the enlarged retinal image compensates for the diminished visual acuity. These cases, however, are seldom encountered, and a concave lens, properly selected, almost always improves both near and distant vision.

Concave glasses diminish the size of the retinal image, especially when the glass is removed farther from the eye. The retinal image is larger in myopia than in emmetropia, but if the correcting lens is exactly 13 mm. in front of the cornea, the image is of the same size as in emmetropia.

Concave lenses act as prisms when the visual line passes through any portion except the optical center. The optical centers should always be separated by a space equal to, and never less than, the interpupillary distance, except in those



cases of weakness of the internal rectus muscles where it is advisable to increase the distance between the centers. This produces the effect of a prism with its base inward—that is, it lessens the amount of convergence which otherwise would be required. The deviation may be calculated from the focal distance of the lens and the amount of decentering. The distance the optical center is displaced, divided by the focus, equals the tangent of the angle of deviation. Myopes with decided esophoria often read more comfortably without than with glasses.

The painful glare of light sometimes caused by wearing concave glasses may be modified by tinting them.

The reading-glasses for myopes are described under Presbyopia.

**Astigmatism.**—In the preceding forms of ametropia, H. and M., the cornea has been considered as an ellipsoid of revolution, so that planes passing through it in various directions, vertical, horizontal, and oblique, produce sections having an equal curvature. Equal refraction consequently takes place in these different planes. Variations in the curvature of the different meridians produce differences in their refractive power; in some of these meridians the eye must, therefore, be ametropic. Three conditions may arise:

1. The eye may be emmetropic in one meridian and ametropic (either H. or M.) in the others.
2. The eye may be ametropic (H. or M.) in all meridians, but in different degrees.
3. The eye may be ametropic in all meridians, but in some H. and in others M. (H. and M.).

It is convenient to designate the different parts of the eye by imaginary lines, similar to those employed in geography.

The *axis* of the eye is a line drawn from the center of the cornea through the center of the ball. Passing through the center of the lens and the center of rotation, it penetrates the sclerotic between the optic nerve entrance and the macula. The anterior and posterior extremities of this line are the *poles* of the eye.

A great circle extending round the ball perpendicularly to

the axis, and at an equal distance from the two poles is called the *equator* of the eye; other great circles passing through the poles are called *meridians*.

The lens is described in a similar way by its axis, anterior and posterior poles, and equator.

When the meridians of the cornea have an equal curvature, the rays of light gather in one common focus. Frequently the cornea has meridians of unequal curvature producing greater refraction in some meridians and less in others. The rays passing through the meridians of highest refraction reach their focus soonest, while those passing through the less refracting meridians come to a focus farther back.

**Definition.**—*Astigmatism is an ametropia of curvature, and the term is applied to that refractive condition of the eye in which a luminous point—for example, a star—forms an image on the retina, the shape of which image is a line, an oval, or a circle, according to the situation of the retina, but never a point.*

**Seat of Astigmatism.**—Usually the cornea is the seat of astigmatism, but astigmatism may also be produced by an oblique position of the lens, or by the visual line passing eccentrically through the cornea.

When the meridians of the cornea progress evenly in their refraction from the lowest to the highest, the astigmatism is termed *regular*. When the curvature in different parts of the same meridian varies,—and the meridians vary irregularly in their curvature as the result of cicatrices from ulcers or distention of the cornea from inflammation,—the astigmatism is called *irregular*.

Almost all eyes possess more or less *irregular astigmatism*. Usually it is only slight, and gives no serious inconvenience for ordinary vision, but all points of light, such as stars, distant street-lamps, etc., shoot out rays and twinkle as the result of the irregular astigmatism of the eye. The seat of this irregular astigmatism is in the crystalline lens. In the lenses of young people the union of the sectors is visible by three faint lines—the *lens star*; in the adult secondary rays are also visible. Slight differences in the density of the several sectors are sufficient to produce a distorted image of a luminous point.

**Principal Meridians.**—In regular astigmatism the cornea has one meridian with the shortest radius of curvature producing the highest refraction, and another meridian, at right angles to this, with the longest radius of curvature and the least refraction. These are called the *principal meridians*, and may be situated in any part of the cornea, but there is a disposition of the greatest refracting meridian to lie in or near a vertical direction, and of the least refracting meridian to lie in a horizontal direction.

When the meridian of greatest refraction is vertical or nearly so, the astigmatism is described as "*with the rule*"; when the meridian of greatest refraction is horizontal or nearly so, the astigmatism is spoken of as "*contrary to the rule*"; when the direction of the principal meridians approaches  $45^\circ$  and  $135^\circ$ , the astigmatism is often designated "*oblique*."

To simplify the phenomena of astigmatism the principal meridians will be considered as running vertically and horizontally with the greatest refraction in the vertical, and the least refraction in the horizontal, meridian.

**Form of the Image of a Point Focused by an Astigmatic Eye.**—The rays passing into an astigmatic eye, thus considered, are most sharply refracted by the vertical meridian. The bundle of rays, instead of having a round section, forms a horizontal oval, which becomes smaller as the rays travel farther backward; but the vertical diameter of the oval lessens most rapidly until, when the focus of the vertical meridian is reached, the figure becomes a horizontal line, because all the rays are brought to one level and remain diffused only in the horizontal direction.

Farther back the rays, after passing this focus and crossing, diverge again vertically, and the figure becomes once more a horizontal oval; but shorter because the horizontal diffusion is diminished.

Still farther the figure assumes the form of a circle; the diffusion of the horizontal rays has become less, and that of the vertical rays more. The figure becomes next a vertical oval, then a vertical line as the focus of the horizontal meridian is reached. Finally, the section is again a vertical oval,

the horizontal rays, having passed their focus, cross and begin to diverge (Fig. 64).

It is evident from this that no matter what position the retina may occupy, no distinct image can be formed upon it, but there must always be overlapping of the images of the different points of an object, causing a blur or a wrong impression of its outline.

**Symptoms.**—In this manner the acuteness of vision is diminished by astigmatism. Letters are not distinctly seen, some letters being confused with others—H and N, B and S, F and P, K and X, V and Y. The overlapping of the diffusion areas in the retinal image produces, in high degrees of astigmatism, an apparent doubling of the object. The indistinctness of



FIG. 64.—Retinal images of a point in the different forms of astigmatism. *A*, compound hyperopic astigmatism. *B*, simple hyperopic astigmatism. *C D E*, mixed astigmatism. *F*, simple myopic astigmatism. *G*, compound myopic astigmatism.

vision compels a closer approximation of the object, with a consequent strain upon the accommodation.

Astigmatic persons learn to overcome their refractive defect by contracting the lids close together in order to make a horizontal slit. The vertically divergent rays are thus excluded, and the eye, accommodated for the horizontally divergent rays, receives a more distinct though fainter image. There is an almost characteristic facial expression in astigmatism caused by contraction of the lids.

Astigmatism produces an indistinctness in the appearance of fine lines running in certain directions, the direction of the indistinct lines being determined by that meridian which has its focus on or nearest to the retina. This meridian, therefore, will most nearly approach emmetropia; the lines parallel to it will appear indistinct, while those parallel to the opposite

meridian, or the one farthest removed from emmetropia, are most distinctly seen.

In those cases in which the horizontal meridian is emmetropic and the vertical meridian ametropic, fine parallel lines running in a horizontal direction will appear spread out into thick bars, while vertical lines will appear distinct.

To understand this, the student should remember that rays diverge from a horizontal line in all directions; those which pass through the horizontal meridian, if they are not exactly focused, spread out in the direction of the line, causing its extremities to appear somewhat faint in outline, but do not blur its width. The rays which diverge in vertical planes from the different points in the line pass through the vertical meridian. If this is not emmetropic, the breadth of the line

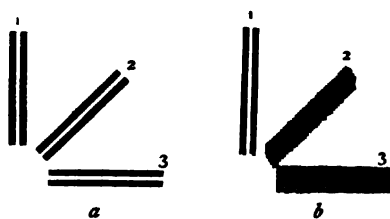


FIG. 65.—Illustrating the appearance of lines running in different directions as seen by (a) the normal eye and (b) the astigmatic eye (Jackson).

appears thicker; but if the vertical meridian is emmetropic, it forms a distinct point in the image, of each point in the object, by bringing the rays which pass through it to a focus. A horizontal line thus appears as a succession of distinct points when the vertical meridian is emmetropic. Vertical lines, in the same way, appear most distinct when the horizontal meridian is nearest to emmetropia, or if oblique lines appear most distinct, the meridian at right angles to their direction is the one nearest to emmetropia. Luminous points are drawn out in the direction of the ametropic meridian, and luminous circles become elongated into ovals.

Astigmatism may be responsible for the most aggravated types of *asthenopia* and most marked symptoms of *eye-strain*. Fully 60 per cent. of functional *headaches* are caused by this

type of refractive error, either alone or in association with other forms of ametropia. The headache may vary from a moderate frontal distress to violent explosions of pain, and may be situated in any portion of the cranium. Furthermore, all manner of reflex nervous disturbances, vertigo, pseudo-chorea, habit-spasm, epileptiform convulsions, melancholia, neurasthenia, tachycardia, night-terrors, flatulent and other types of dyspepsia, indigestion, and even constipation are the frequent results of astigmatism, not only when the error is of high degree, but commonly, indeed more commonly, when it exists in low grade, and often unassociated with any symptoms which prominently direct attention to the eyes as the cause of the distress. Pains strangely and persistently situated in the nape of the neck, between and under the shoulder-blades, at the end of the spine, and deep in the mastoid may owe their origin to the same cause.

**Regular Astigmatism.**—Regular astigmatism is divided into five varieties, according to the relative position of the



FIG. 66.—Foci of the principal meridians in simple hyperopic astigmatism.



FIG. 67.—Foci of the principal meridians in simple myopic astigmatism.

retina to the foci of the two principal meridians. The focus of the horizontal meridian is represented by H., that of the vertical meridian by V.

**1. Simple Hyperopic Astigmatism.**—In this variety one meridian, usually the vertical, is emmetropic, and the horizontal meridian is hyperopic. The focus of the vertical meridian is on the retina; the focus of the horizontal meridian is behind the retina (Fig. 66); horizontal lines appear distinct.

**2. Simple Myopic Astigmatism.**—The focus of one meridian, usually the horizontal, is situated on the retina, while the focus of the vertical meridian lies in front of the retina. The

vertical meridian is myopic, and the horizontal meridian emmetropic (Fig. 67); vertical lines appear distinct.

**3. Compound Hyperopic Astigmatism.**—All meridians are hyperopic, but usually the horizontal presents the greatest ametropia. The focus of each principal meridian is situated back of the retina, that of the vertical generally being nearest to it (Fig. 68); horizontal lines are usually most distinct.

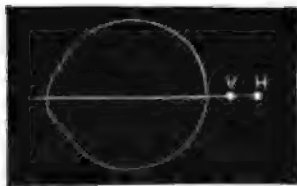


FIG. 68.—Foci of the principal meridians in compound hyperopic astigmatism.



FIG. 69.—Foci of the principal meridians in compound myopic astigmatism.

**4. Compound Myopic Astigmatism.**—All meridians are myopic, but the vertical presents the greatest ametropia. Both principal meridians have their foci in front of the retina, that of the horizontal lying closer to the retina (Fig. 69); vertical lines are usually most distinct.

**5. Mixed Astigmatism.**—The retina lies between the foci of the two principal meridians. The horizontal meridian is hyperopic, and the vertical meridian is myopic (Fig. 70); no



FIG. 70.—Foci of the principal meridians in mixed astigmatism.

lines appear distinct unless the eye simulates myopic astigmatism; in this case the vertical lines appear distinct.

**Recognition of Astigmatism.**—Astigmatism is recognized *subjectively* by the greater distinctness of lines which run in one direction, and the blurring of those lines which run in a direction at right angles to this (Fig. 71). The vertical strokes

of a letter may appear distinct, while the horizontal strokes are hazy.

A diminished visual acuity, unimproved by spheric lenses, in the absence of organic disease of the eye,—for example, opacity of the media or lesions of the fundus, or lesions of the visual centers,—usually is due to astigmatism. Patients frequently complain that letters have a streaked or smeared appearance; a small jet of flame seems to be drawn out in one direction.

Astigmatism is recognized *objectively*, and its degree very closely estimated, by the ophthalmoscope (pages 124–126 and page 131), the ophthalmometer (page 131 and appendix), and skiascopy (page 132).

**Correction of Astigmatism.**—Astigmatism may exist in a very low degree, associated with a much higher degree of hyperopia or myopia, or a marked astigmatism may exist alone, or with ametropia of the other meridians, or finally mixed astigmatism may be present. There are several methods by which astigmatism may be measured:

1. In all cases of hyperopia or myopia, after the highest visual acuity has been developed with spheric lenses, and even if the radiating lines on the dial appear equally distinct, a weak convex and a weak concave cylindric lens should be alternately placed in the trial-frame, in addition to the spheric lens, and their axes rotated through  $180^\circ$ .

If, by this manœuver, vision is improved and the patient enabled to read another line of the test-letters, astigmatism is present. For example, if the vision of a case of hyperopia of 3 D is improved by placing in front of the spheric lens a convex 0.50 D cylinder, with its axis vertical, the glass required is + 3 D sph.  $\bigcirc$  + 0.50 cyl., axis  $90^\circ$  or vertical; but if in the same case the maximum vision previously obtained by + 3 D sph. is not improved by the addition of a convex cylindric lens, a concave cylindric lens should be rotated through  $180^\circ$  in front of the spheric lens. If, under these circumstances, a concave cylinder of 0.50 D with its axis at  $180^\circ$  is found to improve vision and equalize the lines, the formula is + 3 D sph.  $\bigcirc$  - 0.50 D cyl., axis  $180^\circ$ . This



result may be expressed in a simpler form by the formula  $+2.50$  D sph.  $\ominus + 0.50$  D cyl., axis  $90^\circ$  (see page 37).

From this it is evident that any spherocylindric combination, in which the spheric is designated by a plus (+) and the cylinder by a minus (−) sign, unless the cylinder is stronger than the spheric, can be reduced to a simpler form, obtained by subtracting the value of the cylinder from that of the spheric lens; the difference is the strength of the required spheric lens. A cylinder of the same strength as the one first em-

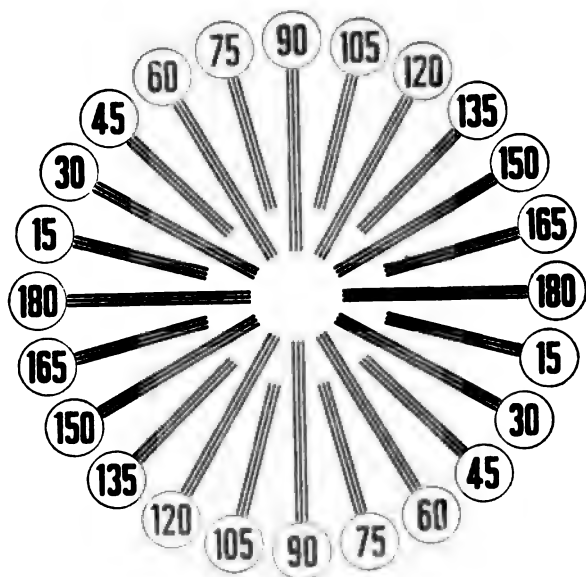


FIG. 71.—Wallace's astigmatic chart reduced to one-sixth of its diameter.

ployed, with its sign changed to correspond to that of the spheric lens, and the axis reversed, completes the process. This method of correcting astigmatism is best adapted to those cases in which the degree is  $0.75$  D or less.

2. The position of the principal meridians is determined by means of the clock-face, Snellen's dial, or a series of lines, as is shown in figure 71.

The most distinct lines correspond to the most ametropic meridian; therefore a *stenopaic slit* is inserted in the trial-

frame, in a direction at right angles to this. If vision is normal in this direction, the meridian must be emmetropic and the astigmatism is simple. The slit is then turned at right angles to its previous direction, and the glass found which gives the highest vision. The astigmatism is represented by this glass. The following are examples :

*Simple Hyperopic Astigmatism.*—The patient sees horizontal lines most distinctly ; the stenopaic slit is placed vertically in front of the eye : and through this  $V = \frac{6}{6}$  ; with the stenopaic slit horizontally placed,  $V = \frac{6}{9}$ , with + 1 D added,  $V = \frac{6}{6}$  ; hence + 1 D cyl., axis  $90^\circ$ , is the glass required.

*Simple Myopic Astigmatism.*—The patient sees vertical lines most distinctly ; the slit is placed horizontally :  $V = \frac{6}{6}$  ; with the slit placed vertically :  $V = \frac{6}{12}$  ; with - 1.50 added,  $V = \frac{6}{6}$  ; hence - 1.50 cyl., axis  $180^\circ$ , is the glass required.

3. The patient may not perceive any difference in the distinctness of the radiating lines until a spheric lens is placed in front of the eye, when some of them become more distinct than the others. The slit is now introduced in a direction at right angles to the distinct lines. Vision is not normal, but a spheric lens improves it, and that lens which gives the best vision with the slit in this direction is selected. The slit is then reversed. The visual acuity is less through the slit in this position than in the previous one, and a higher lens is necessary to secure the best vision. The astigmatism is represented by the difference between the stronger and the weaker lens. This is an example of compound astigmatism, and is corrected by a spheric lens of the same strength as that which neutralizes the least ametropic meridian, and a cylindric lens equal to the difference between the two meridians. The following are examples :

*Compound Hyperopic Astigmatism.*—No lines appear distinct, or perhaps the horizontal ones only slightly more distinct than the others, but a convex glass makes the horizontal lines decidedly more distinct. The slit is introduced in a vertical direction :  $V = \frac{6}{12}$  ;

with + 1.50 spheric lens added,  $V = \frac{6}{6}$ . The slit is now turned in a horizontal direction:  $V = \frac{6}{30}$ ; with + 3.50 D sph. added,  $V = \frac{6}{6}$ . The glass required for such a case is + 1.50 D sph.  $\odot$  + 2 D cyl., axis  $90^\circ$ .

*Compound Myopic Astigmatism.*—No lines are distinct, but a concave spheric lens possibly makes the vertical lines more distinct than the others, if the visual acuity is not too much lowered. The slit is introduced in the horizontal direction:  $V = \frac{6}{60}$ ; with - 5 D added,  $V = \frac{6}{12}$ . The slit is now placed vertically:  $V = \frac{6}{60}$ , - 7 D is added, and  $V$  rises to  $\frac{6}{12}$ . The glass required is - 5 D sph.  $\odot$  - 2 D cyl., axis  $180^\circ$ .

All that has been said in regard to the selection of glasses in myopia applies equally here. It is often impossible to correct the astigmatism accurately in the manner just described, and better results are obtained by the first method—that is, by developing the best possible vision with spheric lenses, and then adding cylinders to still further improve the visual acuity.

*Mixed Astigmatism.*—Hyperopia exists in one principal meridian, and myopia in the other. Usually no set of lines appears plainer than the rest, but the addition of a concave or convex spheric lens brings out some lines more distinctly than the others. Thus a clue to the principal meridians is obtained. With the slit before the eye, a convex spheric lens is placed in position and the slit rotated until the vision becomes more distinct. The hyperopic meridian has then been found.

*Example.*—Suppose the hyperopic meridian to be horizontal and  $V$  to be most improved by + 3 D. The slit is turned to the vertical position, and it is found that a - 4 D gives the best vision. The difference between these two meridians is 7 D. A + 7 cylinder, axis  $90^\circ$ , placed before such an eye would produce a myopia of 4 D, while a - 7 cylinder, axis  $180^\circ$ , would produce a hyperopia of 3 D, consequently with the + 7 cylinder we must associate a - 4 spheric lens, and with the - 7 D cylinder a + 3 D spheric lens. Such a case could be corrected by either of the following formulas: + 3 D sph.  $\odot$  - 7 D cyl., axis  $180^\circ$ ; or - 4 D sph.  $\odot$  + 7 D cyl., axis  $90^\circ$ ; or by means of two cylindric lenses with their axes at right angles to each other, viz., + 3 D cyl., axis  $90^\circ$   $\odot$  - 4 D cyl., axis  $180^\circ$ .

Dr. J. S. Johnson,<sup>1</sup> of St. Paul, employs a method of determining astigmatism, which he calls "the reversal of the clock-dial chart" when it is viewed through successive spheric lenses. The first indication of such a change marks the dividing line between the hyperopia and the astigmatism and between the spheric and cylindric correction. If carried carefully to the point of complete reversal, it will also show the ametropia of highest degree and thus serve all the purposes of the stenopaic slit.

The following additional facts concerning lenses require mention: If a spherocylinder is in position before an eye, and vision is improved by placing before it another cylinder of the same sign (+ or -), with its axis at right angles to that of the first, it shows that a stronger spheric and weaker cylinder are required.

If vision is improved by placing in position another cylinder of the same sign, with its axis parallel to the first, it shows that the same spheric with a stronger cylinder should be adopted.

If vision is improved by placing in position another cylinder of different sign, with its axis parallel to the first, it shows that a weaker cylinder with the same spheric lens is needed.

If vision is improved by placing in position a cylinder of different sign, with its axis at right angles to the first, it shows that a weaker spheric lens with a stronger cylinder must be employed.

4. Astigmatism is best estimated and the correcting glass determined by *objective methods*: skiascopy and the ophthalmometer. These have been referred to and are elsewhere explained (pages 131 and 132). All methods should be tried before the glass is finally ordered, and the highest visual acuity possible should be obtained.

**Ordering of Glasses.**—Glasses are ordered for astigmatic eyes according to the general rules already given. For distance, the full correction is ordered in myopic astigmatism and usually in mixed astigmatism; in compound hyperopic astigmatism the spheric lens is usually weakened to meet the requirements of accommodation, but the full cylindric lens

<sup>1</sup> *Ophthalmic Record*, Oct., 1901.

should be ordered. In simple hyperopic astigmatism it may be necessary to add a concave spheric lens; thus, if the correction under full mydriasis at 4 meters should prove to be + 1.50 D cyl., axis  $90^\circ$ , the formula for the glass to be worn after return of accommodation would be - 0.25 D sph.  $\ominus$  + 1.50 D cyl., axis  $90^\circ$ . In compound myopic astigmatism the spheric lens is sometimes weakened for near work. Simple myopic astigmatism and mixed astigmatism give an opportunity for simplifying reading-glasses, as will be described under Presbyopia.

At present there is no uniform plan for the designation of the meridians in astigmatism, and consequently formulas for glasses intended to correct astigmatism do not have a uniform meaning in all parts of the world. Drs. Thomson and Harlan<sup>1</sup> have conveniently summarized three systems as follows:

1. The zero is placed at the end of the horizontal meridian to the patient's left, and the degrees are counted on the upper semicircle to  $180^\circ$  at his right.
2. Zero is placed at the top of the vertical meridian, and the degrees are counted to the nasal and temporal sides to  $90^\circ$  at the horizontal meridian.
3. The zero mark is placed at the nasal extremity of the horizontal meridian in each eye, and the degrees are counted on the upper semicircle to  $180^\circ$  at the temporal extremity.

The first is the one in almost universal use in this country, the formula for the glasses being written in accordance with the markings on the trial-frame.

**Irregular Astigmatism.**—A low degree of this defect exists in nearly all eyes, but it does not interfere with good vision. When its degree is increased by irregularities of the corneal surface from ulcers and cicatrices, the vision is very much reduced, and when such lesions are extensive, optical therapeutics may be unavailing. Often, however, within the pupil space small areas may be found in which the refraction is tolerably uniform, and vision may be decidedly improved

<sup>1</sup> *Archives of Ophthalmology*, 1893, vol. xxii., pp. 251-261. This paper contains an excellent discussion of this subject and an analysis of the arguments for the various systems.

by lenses—spheric and cylindric. All such cases should be carefully studied by objective methods, and full trial with lenses should be made. Stenopaic spectacles render vision more distinct, but they embarrass the wearer by limiting the field of vision. An iridectomy sometimes improves vision very much by displacing the pupil toward a more regular portion of the cornea.

**Surgical Treatment of Astigmatism.**—It has been proposed to correct astigmatism by incising the cornea with a Graefe knife, or by producing a wound two-thirds of the depth of the cornea with the galvanocautery (Laus). The operation should be performed on the meridian of greatest refraction (Borsch). The author has no experience with these procedures.

**Anisometropia.**—This term includes cases in which one eye is much more hyperopic or myopic than its fellow, or where one eye is astigmatic and the other not, or where myopia exists in one eye and hyperopia in the other. No general rule for the management of cases of this character can be given, but the author agrees with Duane that “in the majority of cases of anisometropia, even those in which the difference in refraction exceeds 2 D, the full correction can be applied with success.” The patient, however, must be required to wear the glasses constantly, and must be willing to bear with temporary discomfort while the eyes are becoming accustomed to the lenses. The causes which give rise to discomfort may be summarized as follows: Diplopia and asthenopia from the unequal prismatic effect of the unequally strong lenses; diplopia from imbalance of the ocular muscles, with the full correcting lenses the double images being more manifest; and difficult binocular vision because the retinal images of the two eyes are of a different size, a cause, however, which is considered fallacious by Duane. Exophoria and hyperphoria are often associated with anisometropia; squint may be caused by this refractive condition and may be materially improved by the use of the correcting lenses. If discomfort ensues, success may follow the attempt to train the function of the more defective eye by temporarily excluding the other from vision.

**Presbyopia.**—The accommodation diminishes gradually from early life onward, and the near point recedes farther from the eye with each succeeding year. As long as it remains within or reaches 30 cm., no material inconvenience in reading is noticed; but when the near point is at a greater distance than this, it is usually not possible to read fine type without the aid of convex glasses. This condition is termed *presbyopia*, and is a normal result of growing old.

**Causes.**—The cause of presbyopia consists in loss of the elasticity of the crystalline lens, which is thus prevented from assuming the increased convexity which constitutes the essential factor of accommodation. This increase of convexity, necessary for seeing near objects, must be supplied to the eye by a suitable lens.

Presbyopia usually begins in emmetropic eyes at the age of forty-five. Unusual visual acuity, or vigor of accommodation, however, may enable a person to dispense with glasses for several years longer. A visual acuity of  $\frac{6}{4}$  permits its possessor to see the same object distinctly at 30 cm., which another individual with an acuity of only  $\frac{6}{6}$  would have to hold at 20 cm. Patients occasionally postpone the time of wearing reading-glasses by holding fine print in a bright light, the resulting contraction of the pupil rendering vision more distinct. Presbyopia is to be distinguished from hyperopia, which is often latent and confounded with it. Correction of hyperopia restores the far point of the eye to infinity.

**Correction of Presbyopia.**—In the first stages of presbyopia, while considerable accommodation still remains, a weak convex lens is required, which enables the person to see near objects by rendering the rays less divergent, as if they came from a somewhat greater distance.

There is still a range of vision from the focal distance of the glass to the near point. A person who has an accommodation of 3 D, and requires + 1.50 D in addition, will have a range from the focal distance of the glass  $\frac{1 \text{ meter}}{1.50} = 66 \text{ cm.}$  to

his near point through the glass;  $3\text{ D} + 1.50\text{ D} = 4.50\text{ D}$ ;  
 $\frac{1\text{ meter}}{4.50} = 22\text{ cm.}$

When the accommodation is entirely obliterated at seventy-five years of age, the convex glass must be stronger. The rays are now rendered parallel, as if they came from an infinite distance, and the object must be held at the focus of the lens. There is, therefore, no range of vision.

The presbyopic glass is determined after the eye has been rendered emmetropic by neutralizing any hyperopia or astigmatism which may be present (for the management of myopia and myopic astigmatism under these circumstances see page 183).

Then the *near point* of vision is carefully determined for each eye separately. The ability to read 1-meter type at 30 cm. is not equivalent to the act of accommodating for 30 cm.; in order fairly to accommodate for 30 cm. the patient should be able to read type which represents normal vision at 30 cm. (see page 45). If the accommodation is normal, the near point will correspond closely with the figures given in the table. The additional refractive power required may then be calculated. Unduly strong glasses should not be employed in approximating the near point, lest the far point be brought too close and serious discomfort ensue. Most persons read at an average distance of from 33 to 40 cm., and in early presbyopia considerable range of vision exists on either side of these points; but at sixty years and later there is little play—the near point and far point are close together. A glass with which the patient reads easily at 33 to 40 cm. may then be ordered, unless visual acuity is much diminished.

*Table of the position of near point at different ages.*

Age.	Accommodation.	Point.
45 . . . . .	3.50 diopters	29 cm.
50 . . . . .	2.50 "	40 "
55 . . . . .	1.75 "	57 "
60 . . . . .	1 "	100 "
65 . . . . .	0.50 "	200 "
70 . . . . .	0.25 "	400 "
75 . . . . .	00 "	∞



At the age of forty-five it is usually necessary to supply a + 1 D spheric lens for reading, provided the eye is emmetropic; if the eye is hyperopic, 1 D + the correction for the hyperopia; if myopia exists, + 1 D is not required. Plus 1 D added to the 3.50 D of accommodation which the eye possesses at forty-five years = 4.50 D; this brings  $\rho$  to 22 cm.

$\left(\frac{100}{4.50} = 22\right)$ , and  $r$  to 100 cm.

At fifty years of age + 2 D is usually required, with the same modifications in case of hyperopia or myopia. This glass, added to the accommodation which the eye possesses at 50,—viz., 2.50 D,—also makes 4.50 D; this brings  $\rho$  to 22 cm., but  $r$  is now only 50 cm. distant.

At fifty-five years, + 2.50 D is the glass usually required, which, added to the accommodation (1.75), gives a refractive power of 4.25 D;  $\rho = 23.5$  cm.,  $r = 40$  cm. If stronger lenses than this are used,  $r$  is brought still closer, and the patient is forced to hold the book near his face. So long as  $V = \frac{6}{6}$ , it

is not necessary to order any stronger glass than this. Sometimes + 3 may be more satisfactory and may be ordered, but most persons prefer a glass which enables them to read, resting the book on the lap or the arm of a chair. It is once more reiterated that these glasses are for emmetropic eyes. In hyperopia with presbyopia they are to be added to the hyperopic correction.

As visual acuity diminishes a stronger lens is necessary to enable the object to be held closer, and thus subtend a larger visual angle. The glass may be increased to 4, 5, 6, or even 8 D. The strong glasses necessitate the close approximation of the object and a corresponding diminution in the field of vision. The only rule in the selection of such glasses is to give that glass which affords the necessary vision with the least inconvenience. With very great diminution of sight, requiring glasses of 8 or 10 D, binocular vision is impossible, and the better eye should be supplied with a correcting glass, and the other excluded from vision.

With binocular vision, the reading-glasses for the two eyes

should be equal in strength; consequently, when a different degree of ametropia exists in the two eyes, a corresponding difference should be made in the reading-glasses.

Sometimes modifications are required in the strength of the glass, to suit particular vocations—for example, reading music, reading in the pulpit, working at a bench, playing cards, etc. Under these circumstances it is necessary to ascertain the distance from the eye at which the work is placed, and to order a glass whose focal distance is not less, but, if possible, somewhat greater than the distance required.

In myopia, myopic astigmatism, and mixed astigmatism, the rules for the selection of reading-glasses call for particular mention. Patients with low degrees of myopia, not higher than 2 D, do not require reading-glasses at as early an age as emmetropic or hyperopic subjects. The amount of myopia may be considered the equivalent of the convex glass suitable for the correction of the presbyopia. A myopia of 1 D, consequently, would enable a person to attain the age of fifty without the necessity of reading-glasses. At that age he would require + 1 D for reading, and at fifty-five + 1.50 D, and at sixty, possibly + 2 D, depending upon his visual acuity. A myope of 2 D could dispense with reading-glasses until the age of fifty-five (often until a later period); then he would require + 0.50 D; at sixty, possibly + 1 D. A myope of 3 or 4 D never becomes presbyopic in the ordinary sense; he can read at any age without glasses. In early life he may wear his correction for distance and reading; later on it is better for him to read without glasses.

In higher degrees of myopia it is necessary to order a concave glass from 2 to 5 D less than the full correction. The age has little influence on the amount of reduction; myopes practically do not accommodate; the degree of myopia and the visual acuity are the two important factors. A concave glass is given which will extend the far point to a comfortable distance. A myope of 6 D would probably require from - 3 to - 4 D for reading; a myope of 10 D, about - 6 D, and a myope of 15 or 20 D would require a reduction of 5 or 6 D from the full correction. In these high grades vision is much

reduced, print cannot be seen unless held close to the eye, so that extension of the reading distance is out of the question. The farthest point at which a book can be read should be determined, and a glass given of the same length of focus. Prisms are often necessary. When the vision is much reduced, myopes will sometimes read best with one eye without the aid of any glass.

A patient with simple myopic astigmatism usually reads best with a convex cylinder of the same number, its axis being reversed. Thus, a patient whose myopic astigmatism is corrected by  $-2$  D cyl., axis  $180^\circ$ , will be comfortable with a  $+2$  D cyl., axis  $90^\circ$ . This glass with the myopic astigmatism produces a myopia of 2 D in all meridians, and because the patient has been accustomed to see through a myopic meridian, he prefers this glass to the concave cylinder which makes him accommodate. As a rule, simple myopic astigmatism may be utilized to determine the reading-glass in patients who have reached the age of thirty-five, provided its degree is not too high. A convex cylinder of a strength equal to the concave cylinder with its axis reversed will be sufficient.

If the degree of myopia thus produced is too great for comfortable reading, a concave spheric lens may be added to the convex cylinder. Thus, an astigmatic eye corrected by a  $-4$  D cyl., axis  $180^\circ$ , would probably require  $-1.50$  D sph.  $\ominus + 4$  D cyl., axis  $90^\circ$ .

If the degree of astigmatism is unequal in the two eyes, a spheric lens is required over one eye to equalize the refraction. For example:

1. R. E.  $-5$  D cyl., axis  $180^\circ$ . L. E.  $-3$  D cyl., axis  $180^\circ$ . This case requires a  $-2$  spheric lens to be added to the right eye—viz.,  $-2$  D sph.  $\ominus + 5$  D cyl., axis  $90^\circ$ , to make its refractive power equal to that of the left,  $+3$  D cyl., axis  $90^\circ$ .

2. R. E.  $-1$  D cyl., axis  $180^\circ$ . L. E.  $-2.50$  D cyl., axis  $180^\circ$ . In this instance, according to the circumstances, age, etc., one of the following combinations may be ordered: R. E.  $+1$  D cyl., axis  $90^\circ$ ; L. E.  $-1.50$  D sph.  $\ominus + 2.50$  D cyl., axis  $90^\circ$ ; or R. E.  $+1.50$  D sph.  $\ominus + 1$  D cyl., axis  $90^\circ$ ,

L. E. + 2.50 D cyl., axis  $90^\circ$ . Both of these combinations equalize the refraction of the two eyes, the first by producing in each eye a myopia of 1 D, the second a myopia of 2.50 D.

When, in cases of compound myopic astigmatism, the myopia amounts to several diopters, the reading-glass is secured by a sufficient reduction of the strength of the spheric without change of the cylindric lens.

When, in lower degrees of compound myopic astigmatism, it is desirable to increase the refraction one or more diopters, the procedure is somewhat different. Thus, if the combination is  $-0.50$  D sph.  $\ominus - 1$  D cyl., axis  $180^\circ$ , and the spheric lens is omitted,  $+0.50$  D is gained; by substituting for the concave cylinder a convex cylinder with its axis reversed, an additional gain of 1 D is secured;  $+1$  D cyl., axis  $90^\circ$ , in this case is equivalent to adding  $+1.50$  D sph. to the original combination. If still more refractive power is desirable,—*e. g.*,  $+2$  D,  $+0.50$  D sph.  $\ominus + 1$  D cyl., axis  $90^\circ$ , gives the additional amount.

In another combination,  $-0.75$  D sph.  $\ominus - 4$  D cyl., axis  $180^\circ$ , it is desired to add  $+2.50$  D for reading. Dropping the  $-0.75$  D spheric lens,  $+0.75$  D of refractive power is obtained; substituting for the concave cylinder, convex 4 D cyl., axis  $90^\circ$ ,  $+4$  D more are gained, making  $+4.75$  D. This is too high, hence it would be necessary to combine  $-2.25$  D sph.  $\ominus + 4$  D cyl., axis  $90^\circ$ , in order to obtain the desired  $+2.50$  D. A simpler method of procedure in this case would be to drop the  $-0.75$  D spheric lens; the uncorrected myopia would then furnish 0.75 D of the requisite 2.50 D, leaving 1.75 to be obtained. A  $+1.75$  D added to the  $-4$  D cyl., axis  $180^\circ$ , would make the proper combination.

In mixed astigmatism, a combination of spheric lens and cylinder is usually employed, and by using a concave spheric and convex cylinder the combination necessary to produce any additional refractive power can easily be found.

If the myopia produced by the convex cylinder alone is greater than the power of the lens it is desired to add, a concave spheric lens equal to the difference is given, thus: To the combination  $-3$  D sph.  $\ominus + 5$  D cyl., axis  $90^\circ$ , it is desirable

to add + 2 D.  $-3 + 2 = -1$ , hence - 1 D sph.  $\ominus + 5$  D cyl., axis  $90^\circ$ , is the glass required. Again, to - 1 D sph.  $\ominus + 3$  D cyl., axis  $90^\circ$ , it is desirable to add + 2.50 D.  $-1 + 2.50 = +1.50$ , hence + 1.50 D sph.  $\ominus + 3$  D cyl., axis  $90^\circ$ , is the necessary glass. The myopia is in this case insufficient.

It is a point of some importance, in ordering reading-glasses containing cylindric lenses, to give attention to the relation of the axes of the cylindric lenses. It has been assumed, for the sake of simplicity, that the axes of convex cylinders are placed at  $90^\circ$  and the axes of concave cylinders at  $180^\circ$ ; this is commonly so, but the exceptions are numerous. It is a frequent condition in astigmatism to have one principal meridian inclined  $15^\circ$  to the right of the vertical in one eye, while the meridian of the same refraction in the other eye is inclined the same amount to the left of the vertical. This produces no serious disturbance in wearing the glasses if they are properly centered, although at first a rectangular figure appears like a rhombus. In a little time the eyes adapt themselves to the glasses, and this appearance is lost.

When the meridians of similar refraction are at greater angles than this, especially if the cylindric lenses are strong, there is often inconvenience in wearing them on account of the prismatic deviation and the unequal distortion of objects which cylindric lenses produce. Occasionally the axes are as much as  $90^\circ$  apart, one at  $45^\circ$  and the other at  $135^\circ$ , or one at  $90^\circ$  and the other at  $180^\circ$ . The glasses now deviate rays from an object in different directions, according as the eye looks through the glasses above or below the optical centers, or to the right or left of them. Such a case would be represented by + 3 D cyl., axis  $180^\circ$ , in right eye, and + 3 D cyl., axis  $90^\circ$ , in left eye. The difficulty is not obviated by ordering a formula like the following: R. + 3 D cyl., axis  $180^\circ$ , L. + 3 D sph.  $\ominus - 3$  D cyl., axis  $180^\circ$ , because the same displacement results. It will be found that the best solution of this difficulty is to ascertain the distance from the eye at which the person usually holds the book, and the relative position it occupies to the eye. The direction of the visual lines may thus be determined, and the optical centers of the

glasses should be so placed that the visual lines will pass through them. There is then no deviation. Of course, this renders necessary a separate pair of glasses for reading. When cylindric lenses with axes in unusual directions are required for distance, the optical centers should bear the same relation

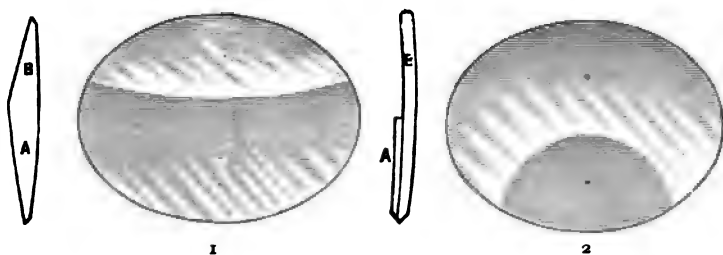


FIG. 72.—Bifocal lenses: 1, Solid bifocal lenses; 2, cemented bifocal lenses.

to the visual lines in distant fixation. These disturbances are aggravated by removing the glass farther from the eye, and conversely the trouble diminishes as the glass is brought nearer to the eye.<sup>1</sup>

**Bifocal Lenses.**—When presbyopic patients require two

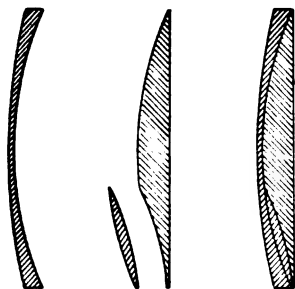


FIG. 73.—Borsch's bifocal lenses.

sets of glasses, one for distance and one for reading and close work, it is the custom, instead of providing them with separate

<sup>1</sup> Consult interesting papers in the *Archives of Ophthalmology*, vol. xviii., by Dr. J. A. Lippincott; in the *Ophthalmic Record*, vol. i., No. 1, by Dr. G. C. Savage; and Dr. R. J. Phillips in the *Annals of Ophthalmology*, vol. ii., p. 31.

sets of glasses, to order *bifocal lenses*. A suitable spheric lens, ground very thin, is cemented on the lower portion of the distance glass, usually upon its inner side. The size of the additional segment varies. Generally one  $12\frac{1}{2}$  mm. in height and 22 mm. in length is sufficient. The shape of the supplementary lens varies. Commonly it is an oval ; sometimes it is made in the form of a circle, and sometimes it is dome-shaped. Solid bifocal lenses are also manufactured. A particularly graceful form of bifocal lens has been designed by J. L. Borsch, of Philadelphia. In this, for the usual presbyopic segment, there is substituted a small lens 15 mm. in diameter, made of flint glass and sunk into the distance lens, which is made of crown glass. The increased refraction of the small lens depends upon the higher index of the flint glass. Its exposed surface is ground to the same curvature as that of the larger lens.

#### SPECTACLES AND THEIR ADJUSTMENT.

After the refraction of the eye has been determined and the proper combination of lenses selected, the glasses should be properly ground, mounted in spectacle-frames, and correctly adjusted to the patient's eyes. Patients should not be allowed to wear glasses until the surgeon has satisfied himself that the formula for the lenses has been faithfully followed by the manufacturing optician.

In order to do this he proceeds as follows : If a simple spheric lens has been ordered, this and a spheric lens from the trial-case, of the same number but opposite refractive character, are placed in close contact and some distant object observed through the combination, while the glasses at the same time are gently moved up and down and to and fro. If the glass is correct, this manœuvre has no influence upon the size or position of the object, which appears exactly as it would if it had been looked at through a piece of plane glass. The glasses are then said to neutralize each other. If the lens ordered does not neutralize the test-glass from the trial-box, a weaker or stronger number is tried until the glass is found which produces complete or nearly complete neutralization. Thick bispheric lenses of different refractive character will not

neutralize each other entirely even if they are of the same number. The convex lens always preponderates. With a suitable "lens-measure" the character of a lens can be quickly determined.

If a cylindric lens has been ordered and has been correctly ground, it will be neutralized by a cylinder of the same number but of opposite refraction, with its axis turned to the same angle as that of the lens ordered. On shaking these two lenses, which are placed in contact, there should be no motion of the object viewed through them. The direction of the axis of a cylinder may be determined by finding the position in which the lens may be shaken without producing any motion of the object. For example, if the axis of the cylinder is vertical, no motion in the object looked at would occur when the spectacle lens is moved up and down. A line drawn on the glass with a pen marks this, and by placing the lens thus marked on a *protractor*, the degree of the angle may be read off.

A combination of spheric and cylindric lenses is to be tested by a spheric lens held on the spheric surface of the spectacle lens, and a cylindric lens held on the cylindric surface of the spectacle lens, and proceeding in the manner just described.

The *optical center* is ascertained as follows: The lens is held by its edges between the finger and thumb, and, care being taken not to hold it obliquely, it is passed from right to left until the test-object (edge of a door or vertical line) forms a continuous line above the lens, through the lens, and below the lens. If the axis of the lens is not exactly in line with the edge of the door, the part seen above and below the lens will not coincide with the part seen through the lens. When a continuous line is obtained through the lens with the object above and below, the lens should be marked with a line drawn across its surface over the part where the edge of the door or line is seen, just as the outline of a figure is traced on a transparent plate. The glass is now turned around so that the line is at right angles to its former position; another portion of the lens is found through which the edge of a door is also seen in a continuous line with the part above and below. This is traced on the



glass with ink, and the intersection of the two lines thus traced marks one extremity of the axis of the lens. In most lenses the distance from the surface to the center is so slight that we may consider this point on the surface as the center, and each lens should have its center marked by a dot of ink. Strong lenses may be centered more easily by using the window-bars, while the glass is held close to them, or the edge of a card or sheet of paper, which is laid on the desk. Still greater accuracy may be obtained by using a card, on which two lines are drawn, crossing each other at right angles; both principal meridians may in this way be found at once; the optical center then lies over the intersection of the lines.

The spectacles should now be placed on the patient, and the position of these centers in relation to the pupil carefully noted. The patient is first asked to look across the room; the centers of the pupils should correspond with the dots on the glasses. Next, the patient is required to look at the finger of the surgeon held at 40 cm. distance, and it will be noticed that the centers of the pupils and the dots no longer coincide, but that the former have passed to the inner side of the latter. If the glasses are for distance or for constant wear, the space between the centers of the lenses should be the same as the interpupillary distance; if the glasses are for reading alone, the distance between the centers must be lessened. The ordinary reading distance being 40 cm., the visual lines converge to this point, and the farther the glasses are from the center of rotation, the nearer the centers should come to each other; therefore, it is necessary to make the distance between the centers of the reading-glasses from 2 to 4 mm. less as compared with those of distance glasses, so that the visual lines may pass through these centers. Thus: The center of the pupil deviates inward about 1 mm. in fixing at a point 40 cm. distant, as the pupil is 11 mm. in front of the center of rotation; a glass placed 13 mm. in front of this would require its optical center to be 1 mm. farther inward than the pupil—2 mm. in all. The two centers should thus be 4 mm. nearer together in reading-glasses than in those for distance.

When glasses are ground with badly placed centers,—that

is, too far apart or too close together,—the most unpleasant consequences may arise: obstinate diplopia, severe neuralgia, headache, and tendency to squint.

The patient should observe some distant object while the interpupillary distance is measured during distant fixation, and then fix his eyes on the finger-tip of the observer, held about 30 cm. from his eyes while the measurement is noted during convergence. There should be a variation of 2 mm. between these two measurements. If the difference is greater than this, there is a probability that the patient has an insufficiency of convergence, and, in this case, the centers of convex glasses should be brought closer together; those of concave glasses placed farther apart. In order to ascertain the amount of deviation which is produced by decentering a spheric lens, see page 24.

Reading-glasses should be tilted forward and placed about 5 mm. lower than those for distance, in order to conform with the depression of the visual line in reading. Spectacles are always to be preferred; but the prejudice of many patients in regard to spectacles will often have to be respected. The tilting forward of eye-glasses is rather an advantage in reading, and in myopia the effect of this tilting is equivalent to a cylindric lens with a horizontal axis. This fact accounts for the preference shown by some patients for a simple concave spheric uncombined with a cylindric lens, in spite of the existence of a slight degree of astigmatism.

When separate glasses are required for distance and reading, it is often very inconvenient to make the change from one to the other. The two glasses may be combined in the same frame by making the lower half suitable for reading and the upper half for distant vision. *Bifocal lenses*, as already described, constitute a more suitable arrangement. "Hook fronts" are very convenient for making a rapid change from reading to distant vision, or "half-hook fronts" may be employed.

## CHAPTER V.

### DISEASES OF THE EYELIDS.

**Congenital Anomalies.**—Complete absence of the lids (*ablepharia totalis*), or their partial development (*ablepharia partialis*), is a rare anomaly. If the defect is of such a nature that the lids are wanting and the orbit divested of any covering for the globe, the condition is designated *lagophthalmos*, a name which also, and perhaps more properly, has been given to a contracted state of the eyelids preventing their closure, independent of any muscular paralysis.

*Cryptophthalmos* is a condition in which neither eyelid nor conjunctival sac is present, but the exterior integument passes in front of, and buries an eye more or less developed.

*Cleft eyelid (coloboma palpebræ)* is a fissure, in appearance not unlike a harelip, which may be confined to the upper lid (its most common situation), but which also has been noted in the lower lids, and even in the upper and lower lids on each side. The center of the cleft contains an intervening membranous portion, either movable or pressed against the cornea.

Coloboma of the eyelids is most frequently associated with harelip; rarely with other congenital anomalies in the eyeball. The deficiency may be remedied by a plastic operation.

*Symblepharon*, or a cohesion, either partial or complete, between the eyelid and the ball, and *ankyloblepharon*, or a union between the margins of the lids, are unusual congenital anomalies. Sometimes only the middle portions of the lid-borders are attached by a filamentous band, or the outer angles of the lids adhere, and produce the defect known as *blepharophimosis*.

*Ectropion*, or eversion of the edges of the eyelids, is a rare condition usually accompanied by increased size of the eyeball. *Entropion*, or inversion of the edges of the lids, which in slight degree is said to be normal before birth, has been found associated with *distichiasis*, or the development of supplementary incurved eyelashes.

The operations which are employed to rectify these conditions when of pathologic origin (see page 667) are also applicable here.

*Epicanthus* is a striking congenital anomaly giving rise to an apparent convergent strabismus, owing to the passage of a fold of skin from the inner end of the brow to the side of the nose, covering the internal canthus, its free concave border stretching outward. Thus the caruncle, lacrimal punctum, and, in aggravated forms, a considerable portion of the area of the lids, are hidden. Epicanthus generally is bilateral and is usually associated with ptosis (Fig. 74). The same condition in minor degrees is often seen in new-born children, and disappears with the subsequent development of the face and nose.

The defect may be remedied by excising a portion of the redundant integument from the bridge of the nose, and stitching together the opposed surfaces.

*Congenital ptosis* consists in a drooping of the upper lid over the eyeball. It may be single or double, but never amounts to complete closure. In one variety there is an actual redundancy of the lid tissue; in the other the lid is thin and the skin stretched, owing to imperfect development or absence of the levator palpebræ.



FIG. 74.—Epicanthus and congenital ptosis (from a patient in the Children's Hospital).

This anomaly is often associated with other vices of conformation, especially epicanthus, and with paralysis of the external ocular muscles. It may be corrected by one of the operations described on page 660.

**Erythema of lids** appears in the form of a hyperemia, more or less diffused, under the influence of heat (sunburn), traumatism, and irritating poisons, or as symptomatic of a systemic disturbance.

A *passive hyperemia*, in which the superficial veins of the lids are dilated and the tissue red and slightly swollen, commonly is the result of prolonged bandaging of the eye, and is seen in an *active* state associated with most of the inflammatory diseases of the cornea and conjunctiva.

**Treatment.**—This consists in removal of the cause and the application of a soothing lotion—lead-water or extract of hamamelis.

**Erysipelas** rarely attacks the eyelids as a primary affection, but spreads to them from the contiguous facial area. The chief danger of the affection in this region is its liability to infect the tissues of the orbit, producing compression of the central vessels of the retina and consequent blindness. It may spread to the membranes of the brain and be fatal. The characteristic red, shining, and later brawny swelling, and the formation of cutaneous vesicles and small abscesses, are the symptoms which establish a diagnosis.

The **treatment**, both local and general, demands the same procedures which are applied to the disease when located elsewhere in the body.

**Abscess of the lid (phlegmon)** appears as a localized red elevation, while the entire lid is hyperemic and the conjunctiva injected and often edematous. There are much pain, headache, and fever. This affection is provoked by injury, exposure, and disease of the orbit, and sometimes arises without ascertainable cause, especially in debilitated people and children.

**Treatment.**—Pointing should be favored by hot, slightly carbolyzed fomentations or compresses soaked in boric acid solution. As soon as fluctuation is detected, or even earlier,

a sharp knife may be thrust through the swelling, parallel to the muscle-fibers, and the contents evacuated; the cavity is to be kept clean with an antiseptic fluid.

**Furuncle of the lid** is a localized inflammation of the skin and subcutaneous tissue, presenting symptoms analogous to abscess, which goes on to the formation of a central slough or "core." The surrounding and overlying tissue may become gangrenous in subjects of poor nutrition.

*Malignant pustule*, or *specific anthrax*, caused by the entrance of the *bacillus anthracis* and *malignant edema*, or a form of *spreading gangrene*, are affections rarely seen upon the eyelids. The former usually arises among people whose occupation brings them in contact with diseased animals or decayed animal matter; the latter may follow an injury, but has also been described as an idiopathic affection.

**Treatment.**—According to the condition present, this should include incision, promotion of the separation of the sloughs by hot compresses steeped in boric acid solution, the use of the actual cautery to check the destructive tendency, and antiseptic lotions.

**Hordeolum**, or **stye**, consists of a localized, suppurating inflammation of the connective tissue in the margin of the lid or of one of the glands of the follicles of the cilia (Zeiss's glands). This may remain a tender, circumscribed swelling, which becomes invested with a yellow cap, indicating suppuration, or it may cause considerable pain, with edematous swelling of the entire lid and chemosis of the conjunctiva. It is known by the name *hordeolum externum*, to distinguish it from a *hordeolum internum*, which is the result of suppuration of a Meibomian gland. Some people are subject to a mild type of styes which appear in the form of superficial pustules along the margin of the lid. A characteristic feature of hordeolum is its tendency to recur, and a single stye, or several at a time, may appear again and again for many weeks. Driving in the cold or dust and the strain of uncorrected ametropia predispose to this disorder. Frequent "attacks" of styes indicate derangement of health, and are especially

associated with constipation and menstrual irregularities. Girls about the age of puberty are commonly affected.

**Treatment.**—A styne sometimes may be aborted by the vigorous application of a hot boric acid lotion or an ointment of the red or yellow oxid of mercury; the same end is obtained by painting the inflamed surface with collodion. In the event of failure, suppuration should be encouraged by repeated applications of small compresses steeped in hot water, and on the earliest appearance of pus a deep incision should be made through the base of the swelling, parallel to the edge of the lid.

**Exanthematous eruptions** on the eyelid are found during the course of various of the eruptive fevers. The pustules of small-pox, if they appear upon the eyelids, form by preference at the commissures, and in connection with the follicles of the eyelashes. The subsequent pitting from loss of tissue may cause considerable disfigurement.

Sometimes a pustule declines to heal and forms a chronic *post-variolous ulcer*. *Vaccine vesicles* (vaccine blepharitis) may form on the lid-margins from accidental inoculation—*e. g.*, with the finger-nail previously in contact with a vaccine-pox or vaccine virus. The vesicles may develop into a severe ulcer, and the bulbar conjunctiva may be involved.

**Eczema of the lids**, independently of that variety which is located upon the ciliary margin and which is one of the forms of blepharitis, may appear upon the general cutaneous surface of these structures, usually in association with its presence elsewhere on the face and scalp, and is seen in the *erythematous*, *vesicular*, and *pustular* varieties.

Eczematous eruptions upon the lids are also associated with inflammations of the cornea and conjunctiva, and arise under the influence of prolonged bandaging. Atropin, when it produces conjunctivitis (see page 266), may cause an eczema of the lids and surrounding face.

**Treatment.**—This depends upon the character of the eruption. If this is vesicular, a useful application is a drying powder composed of starch, oxid of zinc, and camphor; if crusts have formed, these should be removed with as little bleeding as possible and with the aid of an alkaline solution, maceration of

the epidermis being avoided, and one of the following ointments employed: Plain oxid of zinc, or equal parts of oxid of zinc and vaselin to which 20 grains of calomel have been added; or subnitrate of bismuth in an ointment. Itching is relieved by the application of *lotio nigra* followed by zinc ointment. If the disease assumes a chronic type, some preparation of tar (*pix liquida* or *oil of cade*) may be used. Good results follow the use of aristol ointment, both in subacute and chronic cases.

As constitutional remedies, quinin, iron, and strychnin are recommended, and arsenic if the type is chronic. Proper regulation of diet, an occasional saline laxative, and good hygiene are important measures.

**Herpes zoster ophthalmicus** is a specific infectious, and possibly contagious, exanthem (Van Harlingen) characterized by an eruption of vesicles, situated upon inflamed bases, over the area supplied by two of the three branches of the ophthalmic, or first division of the trigeminus—viz., the frontal, through its supra-orbital and supratrochlear branches, and more rarely the nasal nerve.

Neuralgic pain, heat, and redness of the skin precede the vesicles, which, varying in size from a pin's head to a split pea, appear in distinct crops or coalesce in irregular patches. At first they contain a clear yellow fluid, later becoming turbid, until at the end of a week or more they dry up, and the brown scabs drop off, leaving beneath decided and often disfiguring scars.

The disease may be mistaken for erysipelas, from which it should be distinguished by the acute neuralgic pain and the formation of the vesicles in the course of a given set of nerves.

Serious involvement of the eye itself, by the formation of blebs upon the cornea, and by inflammation of the iris and ciliary body, is often associated with the disorder. More or less conjunctivitis is always present. The blebs on the cornea rupture and form ulcers, which leave permanent scars, and the iritis and cyclitis may pass on to a destructive inflammation of the deeper coats of the eye (ophthalmitis). Atrophy of the optic nerves and paralysis of the oculomotor have followed



ophthalmic herpes ; a form of parenchymatous keratitis which precedes by several days the cutaneous lesions of herpes has been reported (Terrien).

Inflammation of the tissues of the eye is most apt to occur when the nasal branch is affected, and the vesicles extend to the tip of the nose, because from this branch, through the lenticular ganglion, arise the nerves supplying the iris, ciliary body, and choroid. This is not an invariable rule, and destructive disease of the eyeball may appear even when the nasal branch is not involved. A severe and most intractable neuralgia often remains after the subsidence of the eruption.

Herpes zoster ophthalmicus is more frequently seen among elderly people of feeble nutrition than among adults and young children, but the latter may be attacked even in the absence of constitutional depression.

**Treatment.**—The disease runs an acute course and tends to spontaneous recovery in two or three weeks. Locally, anodynes are useful—lead-water and laudanum, weak carbolic acid lotions, and preparations of belladonna. Ichthyol ointment is valuable. Severe pain must be mitigated by opiates and morphin hypodermically, while the best constitutional remedies are full doses of quinin and iron, and later arsenic. The postneuralgic pain may be relieved by croton chloral hydrate in doses of 5 to 10 grains every four hours, and by the use of a mild galvanic current. If conjunctivitis, keratitis, iritis, or cyclitis arises, this requires the treatment directed to the relief of such conditions, which is detailed in the special sections devoted to their consideration.

**Blepharitis** is the term applied to the various grades of subacute and chronic inflammation of the border of the eyelid, which, for clinical purposes, may be gathered into two groups—*non-ulcerative* and *ulcerative blepharitis*. The former may be studied under several subdivisions:

1. **Hyperemia of the Lid-border** (*Hyperæmia Marginalis*; *Vasomotor Blepharitis*).—The margins of the lids have an unpleasant, slightly swollen, red appearance. Exposure to cold wind or any strain upon the accommodation causes a feeling of heat, followed by burning and lachrimation. The redness

is caused by the passive congestion of the superficial blood-vessels. Scales or crusts are absent or but sparingly present.

**2. Simple Blepharitis** (*Seborrhea of the Lid-border*; *Blepharitis Ciliaris*; *Squamous Blepharitis*).—This variety depends upon an abnormal secretion of the sebaceous glands, and results in the formation of scales and crusts situated on the margin of the lids at the bases of the eyelashes, or adhering to them, and may appear in either a dry or a moist form. Removal of the hardened sebum exposes the skin, shining, red; and occasionally abraded. There is usually slight conjunctivitis. An accompanying seborrhea of the eyebrows and scalp may be present; both lids are invariably affected, and the patients complain of burning, inability to perform close work, and some dread of light.

Exposure to cold and dust and the use of the eyes quickly increase the congestion of the lids. If the disease is of long duration or is subject to frequent relapses, considerable thickening of the lid-margins is evident, due to the inflammation surrounding the glands in the skin and tarsus.

The second, or *ulcerative*, form of blepharitis appears in several grades of severity as a special localization of—

**Eczema upon the Lid-border** (*Blepharitis Ciliaris*; *Blepharitis Ulcerosa*; *Psorophthalmia*; *Lippitudo Ulcerosa*; *Tinea Tarsi*; *Sycosis Tarsi*; *Ophthalmia Tarsi*, etc.).

(a) *Superficial Form (Marginal Eczema)*.—This resembles in general that variety which has been described as hyperemia of the ciliary margin. The patient suffers from “weak eyes” and from frequent attacks of redness and soreness of the borders of the lids, associated with the formation of crusts, small pustules, and ulcers at the roots of the lashes, without, however, seriously interfering with their nutrition or growth.

(b) *Solitary Form (Blepharo-adenitis Ciliaris, a name given by Arlt)*.—This is characterized by the appearance of a circumscribed area of thickening and redness of the lid-margin, upon which the cilia are matted together at their bases by the formation of thick yellow crusts. A single tuft of this kind may be present, or several on one lid-border; the process is frequently unilateral, in this respect being unlike the squa-

mous forms, which are bilateral. Removal of the crusts evacuates a few drops of thin pus from the surface of the ulcer which lies beneath, and the cilia, which usually come away with the scab, have swollen and thickened roots. Spots of eczema at the nares and in the hair of the scalp may be present at the same time, as well as disease of the lacrimal passages.

(c) *Pustular Form (Blepharitis Ciliaris Ulcerosa)*.—This manifests itself as an eczema of the lid-margins, in its worst types involving the four ciliary borders. Thick yellow crusts, which mat the eyelashes, form along the palpebral margins, covering deep ulcers which readily bleed, and which, often crater-shaped, pass inward to the tarsus.

The inflammatory process, if unchecked, seriously interferes with the nutrition of the lashes and the edges of the eyelid. The former become stunted, curled, misplaced (*trichiasis*), or drop out, and may be entirely absent (*madarosis*, *tylosis*). The latter assume a rounded shape, are swollen, reddened, thickened, slightly everted, and deprived of cilia (*lippitudo*, or "blear eye," *hypertrophic blepharitis*), and if the punctum lachrymale is displaced or closed, an overflow of tears adds to the discomfort of the patient.

It is not always possible thus sharply to separate the various types of blepharitis, as they often shade one into the other; nor is it always safe to decide between those which arise from glandular hypersecretion and those which are due to eczema. After the cure of an ulcerative variety, small scales may form resembling the simple or squamous type, while the latter may also lead to, or be associated with, ulcerations.

**Etiology.**—In the majority of instances blepharitis is a disease of childhood, and is common near the age of puberty; the aggravated forms, especially those resulting in chronic changes in the ciliary margins, are frequently seen in adults as the result of neglect. The malady may follow in the wake of an exanthem, particularly measles, and finds many subjects among children of strumous habit, with blond hair and pale complexion. The usual presence of considerable degrees of ametropia has led to the belief that this causes blepharitis

(Roosa). There is no doubt that it aggravates and fosters the condition.

Of considerable importance in the origin of this affection are inflammations of the tear-sac, stricture of the nasal duct, and obstructive disease of the posterior nares, although it may be difficult, in individual cases, to decide whether the blepharitis has caused the closure of the lacrimal passages, or whether this has developed the blepharitis. Finally, some instances appear to arise from an abnormal shortness of the lids, resulting in their insufficient closure during sleep (Fuchs).

Staphylococci are found in the pustules. Stubborn varieties may depend upon eczema seborrhoicum of the face; rarely the trichophyton fungus is found (*blepharitis trichophytica* of Mibelli). According to Raehlmann, the demodex folliculorum may cause the disease (*blepharitis acaria*). It is, however, a not uncommon inhabitant of the normal eyelid. *Favus*, in the form of dirty, yellowish-white crusts, occasionally appears upon the eyelids, and may be mistaken for blepharitis. Microscopic examination of the crusts would reveal the mycelium and the conidia.

**Treatment.**—This differs with the type of the disease, but in all cases the refraction of the eye should be ascertained and any anomalous condition corrected with suitable glasses. This will often cure an ordinary hyperemia of the lid-margin, but if it is not sufficient, in addition to soothing lotions, the daily use of an eye-douche is most serviceable, employed as follows:

A suitable vessel, to which is attached a rubber tube having at the lower end a small tin arrangement, containing many perforations like the rose of a watering-can, is filled with water of a temperature of 68° F., and held a short distance above the head, the water being allowed to play for several minutes upon the closed eyelids. The douche may be made more acceptable by the addition of a little *eau de cologne* or alcohol. This method, recommended by Koenigstein, is most efficacious. Stimulating salves do not yield good results in this variety, but the edges of the lids may be anointed with almond oil or vaselin.

In the cases classified among the seborrheas all crusts and

scales should be removed by alkaline solutions (bicarbonate or baborate of soda, gr. viij-f3j) or with a 5 per cent. solution of chloral (Gradle), and one of the following ointments applied once or twice daily: yellow oxid of mercury (gr. j-3j), zinc ointment, or the salve advised by Gradle:

Milk of sulphur, . . . . .	3 grains
Resorcin, . . . . .	3 "
Vaselin, . . . . .	100 "

Great care must be exercised to remove the crusts from all the ulcerated varieties, either with the lotions which have been mentioned or, after softening, with forceps, before the application of any salve. Red or yellow oxid of mercury or dilute citrine ointment is suitable; ichthyol (2-10 per cent. of the ammoniacal salt) is also advised.

In chronic cases all loose cilia should be extracted with epilating forceps, and any deep ulcers should be touched with the point of a crayon of nitrate of silver, or penciled with a solution of the same drug, or treated with a mixture of corrosive sublimate in glycerin (1 : 100 to 1 : 30—Despagnet). In severe forms, or when it is desirable to try other remedies, the following formulas will be found useful:

Diachylon ointment, . . . . .	15 grains
Vaselin, . . . . .	240 "
Boric acid, . . . . .	30 grains
Simple ointment, . . . . .	300 "
Aristol, . . . . .	15 grains
Vaselin, . . . . .	
Lanolin, of each, . . . . .	75 "

If the lacrimal passages are obstructed, they must be rendered patulous, and in all cases the anterior and posterior nares should be explored for disease.

The constitutional remedies include iron, quinin, and, if struma is present, cod-liver oil and lactophosphate of lime, with iodid of iron or syrup of hydriodic acid.

Blepharitis may be a mild affection and yield readily to treatment; or it may be stubborn, and require constant attention and frequent change in local measures to prevent deformities in the lid-margins.

**Phthiriasis (blepharitis pediculosa)** occurs when the pediculus pubis or crab-louse forsakes its seat of predilection and finds a habitat among the eyelashes. The cilia appear sprinkled with a fine dark powder—the eggs of the parasites—which are usually found partially buried, head foremost, in the hair-follicles. There are some itching and redness. The affection in most instances has been observed in children. The lice may be removed by the application of blue ointment or a careful penciling with a strong bichlorid solution.

**Syphilis of the Eyelids.**—Syphilitic affections of the eyelids exist either as the primary sore or as secondary or hereditary manifestations. A chancre usually appears on the area included by the lid-borders and inner canthus, the tarsal conjunctiva and the cul-de-sacs (deBeck). The lesion begins as a pimple which gradually develops into a characteristic, somewhat saucer-shaped ulceration, with rather rounded edges and indurated base. The lymph-glands in front of the ear and at the angle of the jaw are enlarged. Contagion has often occurred by the application of the lips or tongue of an individual suffering from mucous patches in the mouth—as, for instance, in the act of kissing; or by the filthy practice of attempting to remove a foreign body with the tip of the tongue. Soiled fingers have also carried the contagion.

It is possible to mistake the affection for a sty, suppurating chalazion, ulcerated tear-sac, vaccine ulcer, or small rodent ulcer.

**Treatment.**—Locally, the ulcer may be dressed with black or yellow wash. As soon as positive secondary manifestations are sufficiently evident to settle the diagnosis, the ordinary antisyphilitic remedies should be exhibited.

The lesions of *secondary syphilis* upon the eyelids require no special description.

Among the later manifestations *gummas* of the skin of the lid, which break down into ulcers,—so-called *tertiary ulcers*,—are described.

A papular eruption may appear upon the eyelids of children, the subjects of hereditary syphilis, shortly after birth. A form of blepharitis, characterized by sharply ulcerated spots,

has been described as the result of hereditary syphilis, and in subjects of this dyscrasia absence and falling-out of the eye-lashes have been seen. The latter condition also arises during secondary syphilis.

**Tumors and Hypertrophies.**—A variety of growths, cystic and solid, are found upon the eyelid and its border. Along the latter, *warts* or *papillomas* are common. These are benign, except when in elderly people, through irritation, they may take on an epitheliomatous nature. They should be cut off and their bases should be cauterized.

Small clear *cysts* are common along the ciliary margin, often giving rise to considerable irritation. They should be punctured.

A reddish, wart-like mass may occur at the mouth of a Meibomian gland-duct. This is to be treated like an ordinary wart.

*Angiomas (nevi)* are congenital growths, and exist either as bright red spots or in the form of elevated *cavernous*



FIG. 75.—Cornu cutaneum of the upper eyelid (from a patient in the Jefferson Medical College Hospital).

growths, which may assume large proportions and extend from the lid to the forehead and temple. They should be dealt with early in their existence, lest they spread into the orbit.

That operative interference should be practised which promises the least subsequent deformity to the lid. When small, they may be excised or cauterized with nitric acid; if of a larger variety, their blood-vessel structure may be destroyed with galvanocautery needles; or *electrolysis* may be tried, three gold-plated needles attached to the negative pole being inserted in various positions in the nevoid tissue, while the

positive pole is attached to some distant point—for example, the arm. The *séance* should last from ten minutes to half an hour, according to circumstances. Injections of liquor ferri subsulphatis are not to be recommended. It is possible sometimes to excise large cavernous angiomas, and if there is not sufficient skin to cover the defect immediately, to accomplish this subsequently by skin-grafting. Occasionally ulceration occurs in an angioma and is followed by serious hemorrhage.

*Cutaneous horns (fibroma; molluscum fibrosum)* occur as connective-tissue new growths, either sessile or pedunculated, sometimes associated with numerous similar tumors elsewhere on the body.

*Neuromas*, of the plexiform variety, and *lipomas* are benign growths which should be removed by careful dissection. The latter growth sometimes appears in the form of an extensive accumulation of fat in the connective tissue of the lid, causing it to droop over the cornea, and produces the condition to which the name *ptosis lipomatosis* has been given. The mass should be dissected out, but complete mobility of the lid



FIG. 76.—Neuroma of the right upper eyelid and adjacent temporal region (from a patient in the Philadelphia Hospital).

is not always regained, owing to failure in the power of the levator palpebræ. *Fat hernias* of the upper lid have been described by Schmidt-Rimpler, as the result of a congenital extension of the orbital fat through a defect in the orbicularis muscle.

Rare forms of benign tumors are *adenoma* of the sweat-glands and their follicles, *papilloma* of the ciliary border, and *enchondroma* of the tarsus.

**Xanthelasma** (*xanthoma*) is a connective-tissue new



growth, with fatty degeneration, usually seen in the form of narrow, semicircular patches, most common upon the upper eyelids, although all four lids may be affected. The patches are yellow or buff-colored, and on a level with the surrounding skin, or slightly raised above it.

Excision, if this may be performed without producing ectropion, is the simplest method of treatment. Electrolysis has also been recommended. The growth produces no irritation.

**Chalazion** (*Meibomian Cyst*; *Tarsal Tumor*).—This is a small tumor due to a chronic inflammation of a Meibomian gland and the tissue which surrounds it. The growth begins by retention of the secretion of the Meibomian gland, followed by a peri-adenitis and destruction of the tarsal cartilage, with passage of the tumor toward the conjunctiva (*internal chalazion*) or to the skin (*external chalazion*). Usually the process is a *chronic* one; sometimes it assumes an *acute* nature, and there is moderate inflammatory reaction. A chalazion may form in the excretory duct of a Meibomian gland, and then projects in a nipple-like body from the edge of the lid. Chalazia may be single or multiple, and in severe cases recurrences may be frequent until a chronic infection of the Meibomian glands and alteration of the tarsal cartilages take place. To this condition Weymann has given the name *tarsadenitis Meibomica*.

**Cause.**—The cause of chalazia is not known, although Deyl and Hála maintain that they represent an infectious, bacterial process, the active bacilli being identical with xerosis bacilli. They may be associated with inflammation of the border of the lid and stoppage of the duct of the gland. Individuals affected with these growths not infrequently have ametropic eyes, especially when there is a tendency to recurrence in crops, like styes. They are more common in adolescence than in youth, childhood, or in old age.

**Symptoms.**—The tumor grows slowly, unless it is of the acute type, and forms a firm swelling attached to the tarsus. The skin usually is freely movable over it; on the conjunctival surface a discolored patch marks its position. Suppuration may take place in the growth.

A so-called acute chalazion may be mistaken for a sty, from which it is to be distinguished by the more circumscribed character of the inflammation, and by the fact that the sty points in the edge of the lid; and a chronic chalazion for a sebaceous cyst from which it may be differentiated by the firmness of its attachment to the tarsus. A chalazion, a small sarcoma of the lid, and even a beginning glandular carcinoma have been confounded.

**Pathologic Anatomy.**—A microscopic examination reveals a collection of cells, the majority of which are of the small round variety, having their origin in the acini of the Meibomian glands. Sometimes large multinuclear (giant-) cells are evident, though inoculation experiments have shown that these are not tubercular in type. The central part of the growth later undergoes a mucoid or colloid degeneration, and a cavity appears, which is filled with a cloudy fluid. There is no true capsule, and there are consequently no characteristics of a true cyst.

**Treatment.**—It is sometimes attempted to produce resolution by the inunction over the swelling of a resolvent ointment. The following may be tried:

Yellow oxid of mercury, . . . . .	2 grains
Vaselin,	
Lanolin, of each, . . . . .	30 "

Or—

Iodid of cadmium, . . . . .	10 grains
Vaselin, . . . . .	60 "

The skin should first be prepared by frequent applications of hot water.

The only radical measure is removal by means of an incision, according to the method described on page 659.

The malignant growths which appear upon the eyelids are *sarcoma*, *carcinoma*, in the form of *epithelioma* or of *rodent ulcer*, and *lupus*.

**Sarcoma** occurs as a primary tumor in both upper and lower lids, about 50 cases being on record, and usually is seen in children. According to Veasey, who, with Wilmer, has

analyzed the literature, the youngest subject was seven months old and the oldest seventy-six years. At first the growth is slightly elastic, and the skin moves over it freely, but the tendency is to rapid growth, ulceration, and involvement of the orbit. The various types of sarcoma have been seen in this region, both pigmented and non-pigmented, and the tumor has been known to follow a contusion.

An early removal of the growth is urgently indicated, but even then there may be local return or metastasis.

**Carcinoma** of the eyelid often appears in the form of *rodent*



FIG. 77.—Destruction of eyeball and orbital tissues by a rodent ulcer: five years between the two stages (from a patient in the Philadelphia Hospital).

*ulcer* (Jacob's ulcer), which is a type of epithelial cancer, being, according to F. H. Montgomery, practically a superficial carcinoma of the tubular variety. It is characterized by slow ulceration and non-involvement of the neighboring lymph-glands, and is usually seen in elderly people.

The growth begins as a pimple, over which a crust appears.

Gradually an ulcer forms, which slowly spreads with indurated and elevated edges, and, if unchecked, involves all the tissues and destroys the eyeball. Often many years elapse before the ulcer attains any considerable size. The most common point of origin is the inner end of the lower lid.

The slow growth and absence of lymphatic involvement, together with the age of the patient, suffice to distinguish rodent ulcer from a tertiary syphilitic sore.

It may be confounded with lupus, but the latter occurs in younger subjects, is more inflamed and less indurated, the

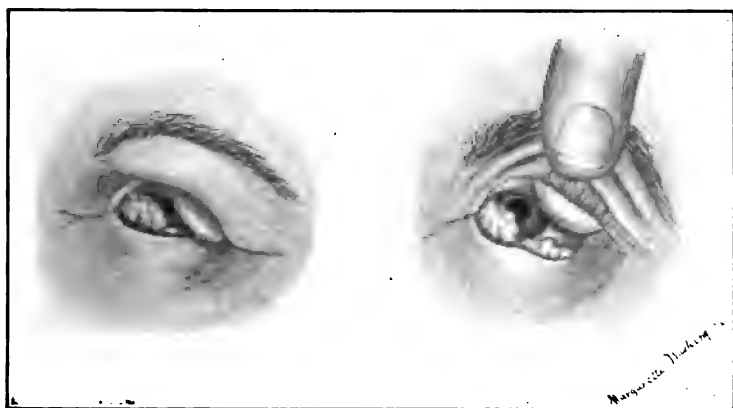


FIG. 78.—Epithelioma of eyelid encroaching on eyeball (from a patient in the Philadelphia Hospital).

ulcerations proceed from many points, and are generally associated with lupus elsewhere in the body.

Instead of rodent cancer, an *epithelioma* with the ordinary clinical characteristics may attack the eyelid (Fig. 80). *Glandular carcinoma*, having its point of origin either in the Meibomian or in Krause's glands, is a rare form of cancer.

**Treatment.**—Certain local remedies, as aristol, chlorate of potassium, and injections of pyoktanin, have been recommended, but the proper treatment is excision. This must be undertaken at an early date, to prevent the necessity of extensive plastic operations to replace the excised tissues. If the disease is advanced, Canquoin's paste, chloracetic acid, scrap-

ing, or the actual cautery may be employed to check the ulceration. Treatment with the X-rays is advisable in cases not suited to operation.

**Lupus vulgaris** is a cellular new growth composed of variously shaped, reddish tubercles, which usually terminate in ulceration and extensive cicatrization. As this disease commonly appears on the face, it may also involve the eyelids.

The process begins in youth, often before puberty, and is slow in its course. The ulcers are apt to start from a number of points which coalesce; their edges are soft, and the discharge is offensive. *Syphilitic ulcers*, on the other hand, are deeper, more excavated, with harder margins, and their course is more rapid.

**Treatment.**—Local application of caustic paste, erosion with a curet, and the actual cautery have been employed, and, at one time, injections of tuberculin.

**Leprosy.**—Leprosy attacks the eyelids very frequently. According to Lopez, two-thirds of those affected with this disease suffer from lesions in this region. These consist of anesthetic patches of color slightly different from that of the surrounding integument, tubercles, loss of the eyelashes and eyebrows, and ectropion and entropion, the former occurring with extraordinary frequency.

**Elephantiasis Arabum**, a chronic hypertrophic disease of the skin and subcutaneous tissue, has appeared in the upper eyelid in consequence of an injury, but may also be congenital. *Elephantiasis telangiectodes*, or that disease which consists in a hypertrophy of the skin and connective tissue, together with fatty tissue and distended vessels, occurs in the upper eyelid as a congenital affection.

**Tarsitis**, or inflammation of the tarsus, is usually syphilitic in origin, and presents great thickening of the tarsus, owing to diffuse gummatous infiltrations (Fig. 79). As a rule, it is chronic in course; in rare instances an acute form has been described. As an idiopathic affection, the disease resembles a chronic marginal blepharitis, with the formation of crusts and ulcers at the mouths of the hair-follicles, but differs from the latter condition by the presence of considerable thickening

and induration of the tarsus. Alteration of the tarsus, owing to chronic infection of the Meibomian glands, may arise and has been referred to. Suppurative tarsitis has occurred.

**Treatment.**—If syphilitic, tarsitis is amenable to the ordinary remedies; if idiopathic, much the same treatment de-



FIG. 79.—From a photograph of a patient with syphilitic tarsitis under the care of Dr. Randall, in the Children's Hospital.

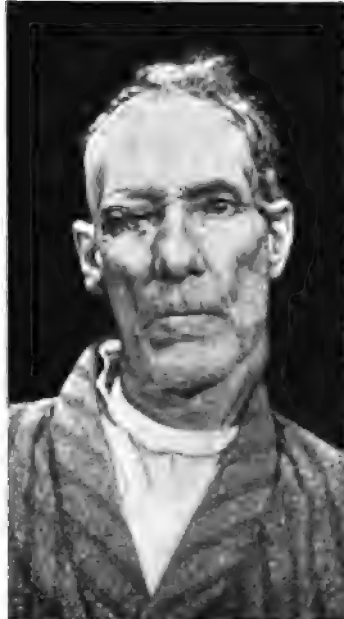


FIG. 80.—Epithelioma of the eyelid (from a patient in the Jefferson Medical College Hospital).

scribed in connection with chronic blepharitis is applicable, especially the use of resolvent ointments.

**Blepharospasm**, or an involuntary contraction of a portion or the whole of the orbicularis palpebrarum, appears as either a *clonic* or a *tonic* cramp.

The former variety, in its simplest forms, consists in a twitching of a few fibers of the muscle, most commonly in the lower lid, very annoying, and often the cause of undue alarm. It arises from the strain of ametropia, prolonged eye use, and deficient amplitude of accommodation.

The *treatment* comprises the prescription of glasses and a general tonic, a very suitable one being an elixir of quinin, iron, and strychnin, provided the last remedy does not aggravate the affection, in which case it may be omitted from the combination. In stubborn cases fluid extract of gelsemium will afford relief. Conium internally, and the extract locally, have been recommended.

Children are often affected, especially during their early school years, with undue winking of the eyelids, associated, at times, with jerky movements of the facial and other muscles. This form of nervous disorder is designated by Weir Mitchell "*habit chorca*."<sup>1</sup> Almost invariably blepharitis, follicular conjunctivitis, and errors of refraction and heterophoria will be found as exciting causes. Suitable glasses and appropriate local remedies, together with the exhibition of Fowler's solution, will usually bring about a cure.

*Tonic cramp* of the orbicularis follows the introduction of foreign bodies into the eye, the presence of inflammations of the cornea and conjunctiva, and fissures at the angles of the lids.

More rarely a persistent lid cramp occurs, without obvious cause, and is unrelieved for weeks and even months. When the eyes are finally opened, there may be temporary blindness, without corresponding ophthalmoscopic changes; or permanent loss of vision, with gross lesions in the eye-ground.

Tonic cramp appears to be a form of reflex action, arising through irritation of the peripheral trigeminal filaments. The blindness which has been observed in certain instances has been explained as cortical in nature, owing to the long absence of peripheral stimulation, or as an example of the "forgetting volition" of the sensory perceptions, analogous to the suppression of the image in alternating strabismus (Samelsohn). If gross changes appear, these have been explained by pressure of the closed lids upon the ball.

The *treatment* demands the removal of any peripherally exciting cause—fissure, foreign bodies, phlyctenules, etc. Hypodermic injections of morphin have been used to control

<sup>1</sup> Gowers gives the name "*habit-spasm*" to the same affection.

the trigeminal irritation, and in severe cases section of the supra-orbital nerve has been performed. Conium and gelsemium in the form of the fluid extract may be tried. They should be pushed to the point of tolerance.

**Ptosis** (*blepharoptosis*) is that condition in which the upper lid droops entirely or partially over the eyeball, and cannot be voluntarily raised. It is either congenital (page 193) or acquired by reason of the development of fatty or other accumulations in the connective tissue of the lid (page 205), or it arises from paralysis of the oculomotor nerve; in rare instances from lesion of its cortical center. In some cases of unilateral congenital ptosis, usually on the left side, while the eyelid cannot be voluntarily raised, it is elevated when the jaw is moved during eating (contraction of the levator in association with the external pterygoid) (see also Ocular Palsies).

**Treatment.**—The medicinal treatment calls for the exhibition of those remedies which control the supposed cause of the palsy—mercury and iodids in syphilis, salicylic acid in rheumatism.

The surgical treatment will be found on page 660.

**Blepharochalasis**, or relaxation of the skin of the lid, due to atrophy of the intercellular tissue, has been described by Fuchs and other writers, and may be remedied by excising appropriate portions of the relaxed tissue and uniting the cut edges with sutures.

**Lagophthalmos**, or an inability to close the eyelids, is either paralytic or non-paralytic, and usually results from paralysis of the facial nerve, as in Bell's palsy, but also occurs in tumors of the orbit, exophthalmic goiter, and staphyloma. The highest grade of lagophthalmos appears as a congenital defect (page 192).

The chief danger of the affection is ulceration of the cornea from exposure, rendered all the more certain should disease of the trigeminus also exist.

**Treatment.**—In paralytic lagophthalmos the primary cause of the affection must be treated: in the non-paralytic varieties, and in any form in which the vitality of the cornea is



threatened by its exposure, the operation of tarsorrhaphy may be employed (see page 664).

**Symblepharon,**<sup>1</sup> or a cohesion between the eyelid and the ball, may be complete or partial, acquired or congenital (page 192). The most usual causes are injuries, especially burns with acids or lime. Symblepharon also follows diphtheritic conjunctivitis, trachoma, pemphigus, and occasionally purulent conjunctivitis; but the shortening of the conjunctival sulcus, which occurs by a species of drying of the conjunctiva, presently to be described, must not be confounded with a true symblepharon. The attachment may be merely slight

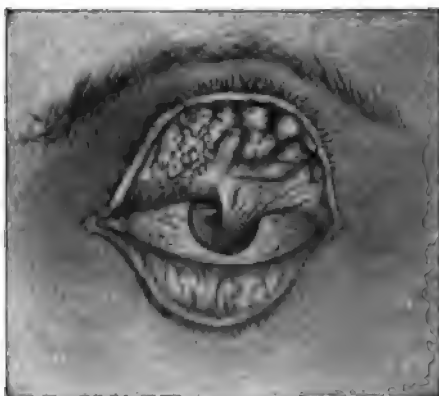


FIG. 81.—Symblepharon, the sequel of purulent conjunctivitis (from a patient in the Philadelphia Hospital).

bands between the conjunctival surface of the lid and ball, or, in the more complete cases, the cornea may also be involved in the cicatricial union, and vision be seriously disturbed. The lower lid is most usually involved in the process; the upper may also participate (Fig. 81).

**Ankyloblepharon,** or that condition in which the borders of the two lids have grown together, may be congenital or acquired, and, like the preceding affection, partial or complete.

The same causes which originate symblepharon are here active, and varieties are described in which the union takes

<sup>1</sup> Symblepharon really belongs to diseases of the conjunctiva, but is conveniently inserted in this place.

place, not by a growing together of the lids, but by the organization of a membrane, the result of croupous conjunctivitis.

**Blepharophimosis** is the name given to that condition which arises through a contraction of the outer commissure of the lids, and results in shortening of the palpebral fissure.

It is commonly seen in cases of long-standing conjunctivitis with irritating secretions, for instance, in chronic conjunctivitis and in some of the forms of granular lids.

**Treatment.**—After an injury, or during the course of a local disease, likely to result in one of these complications, scrupulous care must be exercised to avoid it. The formation of granulation tissue may be broken up with a probe, and it has been advised to place a piece of gold-beater's skin or the thin skin from the inner surface of an egg-shell (Coover) between the lid and the ball to prevent adhesions.

The surgical treatment of these affections is described on page 664.

**Trichiasis ; Distichiasis.**—*Trichiasis* is that affection in which the lashes are misplaced and turn inward against the eyeball; *distichiasis* is that condition in which incurved rows of supplementary cilia are developed from the intermarginal part, close to the opening of the tarsal glands.

The most usual causes of trichiasis are chronic inflammations of the lid-borders—blepharitis and granular conjunctivitis. Distichiasis, in rare instances, is congenital, or develops about the age of puberty, but occurs also as the result of the diseases named.<sup>1</sup> The cilia rubbing against the cornea produce constant irritation, and may lead to ulceration.

**Treatment.**—If not too numerous, the lashes having a faulty direction should be removed with cilium forceps, and when they grow again, the procedure repeated; their reappearance may sometimes be prevented by destruction of the hair-follicles by galvanopuncture. Other operations consist of strangulation of the roots of the incurved lashes by a sub-

<sup>1</sup> Raehlmann believes that trichiasis hairs, or "false cilia," are developed from the epithelial covering of the lid-margin in consequence of marginal blepharitis, the result of granular conjunctivitis.

cutaneous ligature, excision, and the various modifications of single and double transplantation of the entire ciliary border (see chapter on Operation).

**Alopecia of the eyelids**, the loss of the lashes depending upon the fact that the patient, usually a hysterical girl, systematically pulls out the cilia, has been described by H. Gifford. The author has seen several cases. Sudden *turning gray of the eyelashes* has been recorded by Hirschberg after phlyctenular disease. The author has seen one case.

**Entropion**, or inversion of the lid, like trichiasis, is most commonly caused in an *organic* form by granular lids, and also follows essential shrinking of the conjunctiva and diphtheritic conjunctivitis. Entropion and trichiasis are often associated.

Two other varieties of entropion are described—*muscular* and *bulbar*. The former is sometimes present at birth from undue development of the orbicularis, and also occurs in a spasmodic type, under the influence of conjunctivitis, keratitis, and foreign bodies; the latter is a falling-in of the lids when the eyeball is shrunken or absent.

**Treatment.**—The spasmodic varieties will usually subside if the exciting cause can be removed. Painting the lid with flexible collodion, which, by its contraction, draws out the inverted border, or fastening this with a strip of adhesive plaster, or pinching up a longitudinal fold of skin and muscle with a *serre-fine* and keeping it in place, occasionally changing the position of the instrument to avoid irritation, are methods advocated in the treatment of temporary entropion. The organic varieties of the disorder require one or other of the operations described on page 667.

**Ectropion**, or eversion of the lid with exposure of the conjunctival surface, is either partial or complete. The disorder is divided into the *acute* or *muscular* and the *chronic* form, or that which results from organic changes.

Acute ectropion usually occurs in children with conjunctivitis and in diseases of the cornea with blepharospasm, when the lids, during examination, become everted and remain so

until replaced. One form of partial muscular ectropion is produced by facial palsy.



FIG. 82.—Ectropion of the upper lid, the result of an injury to the brow and subsequent caries of the margin of the orbit (from a patient in the Philadelphia Hospital).



FIG. 83.—Ectropion of the lower lid, the result of a wound from the tine of a fork (from a patient in the Children's Hospital).

The common causes of the second, or chronic, form of ectropion are wounds, especially such as are caused by dog-



FIG. 84.—Ectropion of the lower lid, caused by caries of the malar bone (from a patient in the Philadelphia Hospital).



FIG. 85.—Ectropion of the upper lid from syphilitic periostitis of the orbit (from a patient in the Philadelphia Hospital).

bites, by laceration of the lid by a sharp instrument, by burns and subsequent cicatricial contraction, by chronic inflamma-

tory conditions of the ciliary margin, by ulceration of the lids as in lupus, and by caries of the orbital border and malar bone. The lower lid is more frequently involved than the upper, but ectropion is also seen in the latter.

**Treatment.**—This varies with the type and degree of the ectropion. In the spasmodic forms simple replacement of the everted lids suffices; in slightly marked grades, with some eversion of the lacrimal punctum, the canaliculus should be partly slit, and, if necessary, the nasal duct should be probed.



FIG. 86.—Ectropion of the lower lid with chronic conjunctivitis and blepharitis (from a patient in the Philadelphia Hospital).

The organic types of the disorder require a plastic operation for the relief of the deformity (see chapter on Operation).

Certain diseases of the eyelids are comprised in a group of functional disorders of the sebaceous and sweat-glands.

**Seborrhea**, or that functional disorder of the sebaceous glands during which their secretion is altered and forms an oily coating on the skin, sometimes accompanied with crusts and epithelial scales, is also seen upon the eyelids. It is usually associated with a similar process in the scalp and eyebrow, and when specially

localized upon the ciliary margins, creates one of the forms of blepharitis already described.

**Treatment.**—Proper hygiene, cod-liver oil, iron, and arsenic, removal of the accumulated sebum by frequent washings, and the application of sulphur and mercurial ointments comprise the most efficient methods of treatment.

**Milium.**—Milia, or small yellowish elevations, consisting of an accumulation of sebum within the distended but closed

sebaceous glands, are common upon the eyelids. They often develop about the age of puberty.

They are caused by improper care of the skin, and may be connected with general constitutional disturbances, dyspepsia, and constipation. They should be opened with a knife or needle, and the contents evacuated.

**Molluscum contagiosum (molluscum sebaceum)** is a disease of the sebaceous glands (according to some authors, of the rete mucosum), characterized by the appearance of rounded papules, about the size of a pea, and of a waxy color. The eyelids are a favorite situation.

The disorder occurs chiefly among ill-nourished children, is believed by many to be contagious, and may arise as an epidemic in homes and asylums. According to some observers, the affection is caused by a parasite belonging to the class *coccidia*, and really is a form of contagious epithelioma. Muetze's investigations indicate that the "molluscum corpuscles" are the result of a degeneration of the epithelial cells caused by the contagion, the nature of which is uncertain.

**Treatment.**—Each molluscum should be incised and its contents forced out.

**Ephidrosis (hyperidrosis)**, or an increased flow of sweat, has in rare instances been observed as a local disorder of the sweat-glands of the eyelids. In cases of unilateral sweating of the face the lids necessarily participate.

**Chromidrosis (seborrhæa nigricans)**, or the formation of a variously colored secretion from functionally disordered sweat-glands, is sometimes located upon the eyelids. It then receives the name of *palpebral chromidrosis*, and consists of a bluish-black discoloration, usually upon the lower lid, which is somewhat oleaginous and can be wiped away.

It is probably genuine in rare instances; in others it is believed to be either a fraud practised by hysterical subjects or due to the deposit of dust upon the surface of the skin affected with seborrhea. Young women are usually those affected.

The *treatment* should consist in general invigorating methods calculated to remove anemia, debility, or nervous

disturbances. Locally, lead-water and glycerin are recommended.

**Sebaceous cysts** occur in the eyelids, most frequently in the outer part, and also in the eyebrow. In the latter situation they sometimes are deeply seated, tightly adherent to the periosteum, and may extend some distance into the orbit. *Dermoid cysts* are also found in this region. Their removal by an ordinary dissection is usually unattended with difficulty.

**Injuries of the Eyelids.**—Incised, lacerated, and contused wounds, edema, emphysema, and ecchymosis are the ordinary results of accidents and injuries to the eyelids.

**Wounds.**—The type of a wound depends largely upon the character of the implement which has inflicted it, and may vary from a simple and superficial incision to a deep cut which penetrates the tissues of the lid and injures the structures of the eyeball lying beneath. In like manner a laceration may be small and unimportant, or may be so extensive as to tear the eyelid from its attachments. Incised wounds in the line of the direction of the fibers of the orbicularis result in the least visible scar, owing to the absence of gaping.

**Treatment.**—Accurate approximation of the edges of the wound should be secured with catgut or silk sutures, and scrupulous antisepsis should be followed. Even considerable laceration may heal with very little deformity if neat adjustment is secured.

**Edema** usually occurs as the sequel of a blow, owing to the loose connective tissue of the eyelids, which readily admits of distention.

Edema not the result of an injury is seen with severe inflammations of the conjunctiva, as part of a general condition (renal or cardiac), with purulent disease of the sinuses, especially of the ethmoid and antrum, and sometimes in a fugitive and not infrequently recurrent form. The last variety has been observed with migraine, at the time of the establishment of menstruation, and spontaneously without apparent cause. Some instances are analogous to urticaria. The eyelid is a common seat of *angioneurotic edema*. Some types of edema,

non-traumatic in origin, have been called *essential edemas*. According to Trousseau, they are often *arthritic* in origin.

**Treatment.**—The application of evaporating lotions, like dilute lead-water and laudanum, associated, if the swelling is great, with a pressure bandage, is a measure which will afford relief. If a general cause is at the root of the trouble, this must receive appropriate treatment.

**Emphysema of the lids** is observed when a fracture of the orbit permits air to escape into the cellular tissue, through a communication thus produced with the ethmoidal or frontal sinus. A soft swelling, crackling to the touch, is the result, which increases in degree when the patient blows his nose and forces the air through the fissured bone. The eyelids may participate in the emphysema of the neck and face sometimes seen after tracheotomy or after stab-wounds of the chest.

**Ecchymosis of the lids**, or a collection of blood in the connective tissue, in its simplest variety constitutes the familiar “black eye,” the common result of a blow. A gradual absorption of the effused blood takes place, requiring a week or longer for its completion, but the skin may retain its black and blue stain for a greater period of time.

Ecchymosis results also in some cases of fracture of the base of the skull, and may be associated with emphysema if a fracture has involved the frontal or ethmoidal cells.

**Treatment.**—Emphysema will gradually subside without local treatment; if the swelling is severe, it has been recommended to prick the tissues and allow the air to escape.

Ecchymosis should be treated with frequent applications of cold water, arnica, lead-water and laudanum, or diluted white extract of hamamelis. If discoloration remains for a long time, the “eye may be painted.” The practice of applying leeches or incising the swollen lid and sucking out the contained blood is to be condemned.

**Burns of the eyelids** are commonly inflicted with hot water, caustics (lye and lime), acids, or are caused by the explosion of powder.

The first agent produces the ordinary vesication, and the treatment should consist in the application of oil, while the



pain may be materially relieved by using locally a lotion of carbonate of soda, or, better, the moistened powder itself.

Burns caused by the other materials are especially dangerous on account of the almost invariable involvement of the cornea and conjunctiva (see page 277). Immediately after a powder burn all loose powder should be removed, and, if possible, each grain picked out of the skin with a fine needle, or, according to Edward Jackson, destroyed by touching it with a fine electrocautery needle. The application for ordinary burns may then be used. Peroxid of hydrogen has also been employed to remove powder grains.

## CHAPTER VI.

### DISEASES OF THE CONJUNCTIVA.

**Congenital Anomalies of the Conjunctiva.**—In addition to dermoid tumors (page 270) certain thickenings of the conjunctiva of congenital origin have been reported. The latter resemble pterygia and extend between the fissures of the lid (Strawbridge). If necessary, excision could be performed.

**Hyperemia of the conjunctiva** (*dry catarrh*; *hyperæmia palpebraris*) is characterized by an injection of the vessels, chiefly of the palpebral conjunctiva, but rarely affecting the ocular expansion of the membrane. The posterior conjunctival vessels (System I.) are involved, but not to the same extent that they are in conjunctivitis. Both an acute and a chronic form exist.

**Causes.**—The strain of ametropia furnishes a large contingent of these cases, while others arise when the refraction error is insufficiently or improperly corrected. Beginning presbyopia, especially in those people who are disinclined to use glasses, and hyperemia of the conjunctiva are often associated; it also occurs with incipient cataract and slight opacities of the cornea, as the result of the effort to obtain clear images.

Local irritants, as dust, foreign bodies, tobacco smoke, cold winds, etc., are common causes, and the abuse of alcohol originates many cases.

Nasal catarrh, lacrimal obstruction, and marginal blepharitis are frequently accompanied by chronic hyperemia of the conjunctiva, which is much aggravated by the establishment of an acute coryza or "hay-fever."

Finally, certain acute hyperemias, which may be recurrent, appear in the form of vasomotor disturbances, and are seen under the influence of general diseases, especially gout.

**Symptoms.**—Direct inspection reveals the congestion of the vessels, not sufficient to produce the velvety appearance seen in conjunctivitis, and unaccompanied by any discharge. Slight swelling of the conjunctival follicles may be present. There are photophobia, some lacrimation, a hot, stinging sensation, aggravated by use of the eyes, which readily “water” and grow uncomfortable, especially by artificial light.

**Treatment.**—This calls for the correction of any refractive error and careful examination into the accuracy of glasses, provided they are worn by the affected individual.

Removal of exciting local causes and attention to the anterior and posterior nares are necessary. Patency of the canaliculi and of the lacrimal passages should be secured.

Locally, boric acid (gr. x- $\text{f}\text{ʒj}$ ) or biborate of soda (gr. v), camphor water ( $\text{f}\text{ʒj}$ ), and distilled water ( $\text{f}\text{ʒj}$ ), may be applied. More active astringents, as alum, tannin, and zinc, are sometimes employed, and stimulating drops, as equal parts of tincture of opium and water or boric acid solution, to which a few drops of alcohol have been added, are useful. Nitrate of silver is not advisable. Douching the eyes with hot or cold water is a valuable adjuvant. Temporary blanching of the conjunctiva may be secured with adrenalin (1 : 10,000) and preparations of suprarenal extract.

If there is reason to suspect any general trouble,—for example, gout,—this must receive attention, and in those varieties believed to be of vasomotor origin a mixture of tincture of nux vomica and fluid extract of ergot may be exhibited.

**Conjunctivitis.**—The conjunctiva is liable to various grades and types of *inflammation* which have certain symptoms in common: (1) Photophobia, not constantly present in all varieties, but commonly seen at some time during the course of the complaint; (2) increased and usually altered secretion; (3) a changed appearance in the membrane, varying from a general injection of the blood-vessels and slight velvety opacity to the development of special pathologic products or the formation of false membrane.

The generic term “*conjunctivitis*” (“*ophthalmia*” of the older writers) is applicable to this entire group of diseases.

Although exact bacteriologic examinations have given rise to a classification of conjunctivitis which has been recommended in place of the older arrangement, our knowledge is not yet sufficiently exact to make it expedient to banish entirely descriptions based upon clinical appearances.

**Simple Conjunctivitis** (*Catarrhal Conjunctivitis, or Ophthalmia*).—This is an inflammatory disease of the conjunctiva, characterized by congestion, loss in the transparency of the palpebral conjunctiva, some dread of light and spasm of the lids, and a discharge sufficient only to glue the lids in the morning, or freer and mucopurulent.

**Causes.**—The etiology is made evident by observing certain varieties :

*Associated conjunctivitis* is seen with eczema, facial erysipelas, impetigo contagiosa, nasal catarrh, bronchitis, and constitutional disorders like typhoid fever and rheumatism. *Exanthematous conjunctivitis*, which accompanies or follows measles, scarlet fever, and small-pox, may be included.

*Mechanical conjunctivitis* results from exposure to wind, dust, and traumatism (*toxic conjunctivitis*, see page 266).

*Symptomatic conjunctivitis* may arise from the strain of ametropia, and is analogous to ordinary hyperemia.

Micro-organisms (staphylococci, streptococci, pneumococci) are present in severe types and explain the contagion; neglected hyperemias and the presence of follicular granulations increase the susceptibility to infection, and scrofulous subjects are peculiarly liable to the disease.

**Symptoms.**—The secretion is at first watery, and, by running over the edge of the lids, may excoriate the surrounding skin, which shows injection of its superficial veins. In certain individuals the lids, especially along their palpebral margins, are slightly edematous.

The secretion soon becomes mucous or mucopurulent, and, according to the grade of the inflammation, gathers in a slightly frothy material only at the commissural angles, or is more freely secreted.

There are a general hyperemia and loss in the transparency of the tarsal conjunctiva, in which the posterior conjunctival

vessels (System I.) are concerned, and later of the fornix, caruncle, and semilunar folds.

Although vision is not usually affected, some secretion may be adherent to the cornea and produce the same haziness in sight that would be present on looking through a dirty glass; and artificial lights, which are most uncomfortable at all times, appear fringed with colored borders.

Photophobia may be entirely absent, or exist in marked degree in those varieties which complicate measles, or which are associated with the development of small superficial ulcers on the cornea. All ages of life are liable to catarrhal conjunctivitis, but the majority of cases are seen in children and young people.

**Prognosis and Duration.**—The prognosis is perfectly good, and the process will usually subside in a few days. One or both eyes may be affected.

**Acute Contagious Conjunctivitis** (*Acute Mucopurulent Conjunctivitis; Epidemic Conjunctival Catarrh; "Pink Eye"; Koch-Weeks' Bacillus Conjunctivitis*).—This form of conjunctivitis was formerly classified as the severe and epidemic type of the variety of conjunctival affection just described. It should, however, be considered as a distinct affection.

**Etiology.**—The majority of cases are caused by a small specific bacillus discovered independently by Koch in the acute conjunctivitis of Egypt, and by Dr. John E. Weeks in New York, and studied by Morax and others in Europe. This bacillus resembles that of mouse-septicemia, and measures 1 to 2  $\mu$  in length and about 0.25  $\mu$  in breadth. It is often associated with a clubbed bacillus (xerosis bacillus). It stains readily with ordinary anilin dyes. Some observers have maintained that the Koch-Weeks bacillus and the influenza bacillus are identical, and that acute contagious conjunctivitis is a manifestation of influenza. All ages, except perhaps the first few days of life, are liable to the affection, which is commonest in warm and changeable weather (the fall and spring), is markedly contagious, and will pass rapidly from one member of a household to another.

It would seem, from the investigations of Gasparini and

Harold Gifford, that acute conjunctivitis may also be caused by the pneumococcus of Fränkel (Fränkel-Weichselbaum capsulated diplococcus). *Pneumococcus conjunctivitis* was first described by Morax and Parinaud, and was supposed by them to be an affection of early childhood. The later investigations of Gasparini, Gifford, and others show that it is distinctly contagious, may attack adults, may be transferred from one eye to another, and may originate a condition clinically very difficult to differentiate from the Koch-Weeks' bacillus conjunctivitis.

**Symptoms.**—The period of incubation is about thirty-six hours, and the disease begins with the symptoms of a mild catarrhal conjunctivitis, but usually on the third day develops into a severe form of conjunctivitis, in which the entire conjunctiva is deeply injected and small hemorrhages may be observed (*hemorrhagic catarrhal conjunctivitis*), the swelling of the conjunctival membrane being noticeable in opaque velvety layers, especially in the region of the retrotarsal fold. Sometimes the bulbar conjunctiva is chemotic, sometimes brightly injected. The lids are glued together in the morning, and occasionally they are decidedly swollen and edematous; the eyes are hot and heavy, and feel as though they contained sand. The secretion is at first thick and ropy, and may be gathered into long strings of mucus. Later, in some cases, the discharge becomes distinctly purulent. The acute stage lasts from four to ten days, and recovery may be expected in about two weeks. Toward the end of the disease, or in what may be known as the subacute stage, the retrotarsal folds are swollen and the papillary body is enlarged. Follicular hypertrophy is at times also observed, and if care is not taken, the affection may last for a long time. Both eyes are almost always affected, sometimes simultaneously and sometimes one a day or two in advance of its fellow. Corneal complications are rare, but occasionally occur (Morax, Shumway).

**Diagnosis and Prognosis.**—The actual diagnosis depends upon microscopic examination and the finding of the specific micro-organism, but the clinical signs are very striking, particularly the character of the secretion, with its tendency to

gather in yellowish masses toward the inner canthus. If the disease is known to be epidemic at the time, or if it is shown to have passed from one member of the family to another, the diagnosis becomes still more certain. According to Gasparini, in pneumococcus conjunctivitis a fine pedicle of fibrin can be wiped off from the everted upper tarsus, which is not met with in pure cases of the Koch-Weeks' bacillus conjunctivitis.

The prognosis is good in the majority of the cases, although relapses and recurrences are common, and one attack does not create immunity. The affection, through neglect, however, may prove exceedingly troublesome, and tends to attack all members of a household, a fact which, in asylums and similar institutions, may prove of serious import.

**Treatment of Simple Conjunctivitis.**—This consists, first, in search for the cause and the alleviation of associated conditions. The patient must be removed from the influence of dust, cold winds, tobacco-smoke, and the like; the under surfaces of the lids should be examined for foreign bodies, and their borders for misplaced cilia. In the earlier stages cold compresses are agreeable and suitable, but later frequent bathings with hot water are more acceptable. At first a solution of boric acid (as collyrium or spray—gr. x- $\overline{f3j}$ ) is useful. The eye should be frequently washed with water and Castile soap.

As soon as the discharge becomes mucous or mucopurulent and the velvety opacity of the conjunctiva forms, a stronger solution of boric acid, to which a few grains of common salt may be added, is advisable; and the everted lids should be painted with a weak solution of nitrate of silver (gr. ij-v- $\overline{f3j}$ ). In place of nitrate of silver protargol (5-10 per cent.), argemamin (2-5 per cent.), and largin (5-10 per cent.) may be employed; of these preparations protargol is very satisfactory. In severe types, with a considerable discharge, bichlorid of mercury (gr.  $\frac{3}{4}$ -Oj) and formaldehyd (1 : 5000) are good collyria.

Other topical medications which have found favor are alum (gr. iv-vij- $\overline{f3j}$ ), sulphate of zinc (gr. ij- $\overline{f3j}$ ), which may be suitably combined with boric acid, biborate of sodium (gr. iv-vij :

f3j), peroxid of hydrogen, Panas's fluid, creolin (1 per cent.), and other antiseptic collyria. Should the thickening of the retrotarsal folds prove stubborn, these may be touched with an alum crystal or a solution of tannin and glycerin. Atropin is not usually necessary unless a corneal ulcer complicates the affection.

The eyes may be protected with smoked glasses, but under no circumstances should they be bandaged or be covered with poultices of tea-leaves (which of themselves may produce conjunctivitis—"tea-leaf conjunctivitis"), bread and milk, scraped potatoes, and the like. It should be remembered that meddling domestic medication of this sort may change a simple conjunctivitis into a serious and purulent inflammation.

At the outset a laxative, followed by full doses of quinin, is indicated; any associated disease of which the conjunctivitis may be a symptom—*e. g.*, rhinitis—requires the usual treatment. Proper hygiene, fresh air, strict cleanliness, and protection from contaminated towels, etc., are evident indications.

**Treatment of Acute Contagious Conjunctivitis.**—This does not differ from the treatment which has already been described in connection with simple conjunctivitis when the discharge becomes mucous or mucopurulent. The author has found great relief follow iced compresses during the height of the affection. In place of the ordinary collyria, chlorid of zinc, one grain to the ounce, is highly commended, especially by Gifford; sulphate of zinc (gr. ij-f3j) is also useful.

**Purulent conjunctivitis** (*acute blennorrhœa of the conjunctiva*) is described under two forms, according as it occurs in the new-born (*ophthalmia neonatorum*) and in adults (*gonorrhœal conjunctivitis* or *ophthalmia*).

**Conjunctivitis Neonatorum** (*Ophthalmia Neonatorum*).—This is an inflammation of the conjunctiva, characterized, in its usual form, by great swelling of the lids, serous infiltration of the bulbar conjunctiva, and the free secretion of contagious pus.

**Causes.**—The affection is caused by the introduction into the eye of the infecting material from some portion of the genito-urinary tract of the mother at the time of or shortly after



birth. The majority of cases, and all severe forms, are associated with a special micro-organism—the *gonococcus* of Neisser. Exceptionally, inoculation occurs *in utero*, owing to the penetrating power of the gonococcus or to infection after rupture of the membranes (*antepartum conjunctivitis*). In some instances streptococci and Loeffler's bacilli have been found with the gonococci (Chartres). Groenouw has shown that ophthalmia neonatorum is not always a true blennorrhœa, but may appear as an ordinary catarrh, and may be produced by various kinds of micro-organisms—pneumococcus, streptococcus, bacterium coli, and perhaps staphylococcus.

Inasmuch as the gonococcus is not invariably present, two forms of the disease have been distinguished—a severe type, caused by this micro-organism, with a tendency to increase in severity and invade the cornea; and a milder type, non-specific, with a tendency to recover. Hence a virulent vaginal discharge is not necessary to produce this condition, except in intense degree, and it probably may arise from the contamination of any mucopurulent discharge during birth, and from injudicious intravaginal antisepsis with strong solutions of mercuric chlorid. Careless bathing of the child after birth and the use of soiled towels and sponges are fruitful sources of infection. Contact with the lochial discharge may originate the disorder, although inoculation with healthy lochia has failed to produce the disease.

The exact time of inoculation has not been determined. Infection is more likely to occur in face presentations and during retarded labors. Boys are attacked more frequently than girls. The disease is said to be more common during summer months in cold climates; in hot countries, during the spring and autumn.

**Symptoms.**—Conjunctivitis neonatorum usually begins on the third day after birth, but may set in as early as from twelve to forty-eight hours after inoculation, or, when it is the result of a secondary infection from soiled fingers, sponges, or clothes, be delayed to a much later date. Almost always both eyes suffer, the one being earlier and frequently more decidedly affected than its fellow.

Four stages of the disease are common, but as these vary in different cases, and more or less rapidly shade one into the other, no very sharp lines need be drawn.

A slight redness of the conjunctiva, with a trifling discharge in the corner of the eye, is rapidly succeeded by great, cushion-like swelling of the lids, with intense chemosis and congestion of the conjunctiva, accompanied by severe pain and discharge. The surface of the swollen lid is hot, dusky red, and tense; the upper lid overhangs the lower, and at first can be everted only with difficulty. The discharge, which



FIG. 87.—Conjunctivitis neonatorum (from a patient in the Philadelphia Hospital).

in the beginning is slightly turbid, soon changes to a yellow or greenish-yellow pus, and is secreted in great quantities.

If the lids are everted during the first day or two of the disease, the conjunctiva will be found to be swollen, red, and velvety, and that upon the eyeball intensely injected; upon the surface easily detached flakes of lymph are found; later, the conjunctiva becomes rough and of a dark-red color, spots of ecchymosis appear, or it is succulent and bleeds easily. Marked chemosis and infiltration of the ocular conjunctiva succeed, forming a hard rim; at the bottom of the crater-like pit thus produced the cornea may be seen. The thick, cream-

like discharge increases, and either flows out from beneath the overhanging upper lid on to the cheek or is packed up in the conjunctival cul-de-sac (Fig. 87).

The lids now may lose much of their tense character, and can be more easily everted; the conjunctiva is puckered into folds and papilla-like elevations, and the discharge contains an admixture of blood and serum. Gradually the disease declines, and in from six to eight weeks the discharge ceases. The relaxed palpebral conjunctiva is thick and granular, looking like the granulation tissue which surrounds wounds. The ocular conjunctiva is also thickened, and positive cicatricial changes may remain.

The chief risk is destruction of the vitality of the cornea, the danger of which is materially increased if this membrane becomes lusterless, dull, and hazy within the first day or two of the disease, and the gonococcus is freely present in the discharge. Frequently small oval ulcers form near the limbus, either transparent or surrounded by an area of cloudy infiltration, which rapidly increase in size; or larger areas of ulceration develop in a more central situation. In many mild cases the cornea escapes without harm. The changes which take place in the cornea are due in part to strangulation of its nutrient vessels by the swollen tissue, but largely to direct infection by the discharge. Corneal lesions do not usually occur in eyes when the discharge is free from gonococci.

After the formation of a corneal ulcer, either its healing and regeneration of the corneal tissue takes place or else perforation occurs.

The result of perforation will depend upon the amount and character of the destruction of the corneal tissue. When the ulcer is central and perforates, the aqueous humor escapes, the lens is pressed forward against the posterior surface of the cornea, and the opening becomes closed with lymph. Restoration of the anterior chamber follows, and the lens returns to its proper position, carrying with it upon the anterior capsule a little mass of lymph. Thus the formation of a *pyramidal cataract* results (see page 441).

Perforation of an ulcer peripherally situated, especially

below, is followed by adhesion of the iris to the opening. The aqueous escapes, and, as the iris and the lens fall forward, the former becomes entangled in the perforation, and is fixed by inflammatory exudation. The adhesion is either on the posterior surface or in the cicatrix, and the resulting dense white scar receives the name, *adherent leukoma*.

If the region of the scar is bulged forward because it is unable to resist the intra-ocular tension, *anterior staphyloma* results. Extensive sloughing of the corneal tissue, with total prolapse of the iris, matting together of the parts by exudation, and protrusion of the cicatrix constitute a *total anterior staphyloma*.

Finally, perforation may be followed by inflammatory involvement of the ciliary body and choroid, and the rapid destruction of the eye through *panophthalmitis*, or a slower shrinking of the tissues, with *atrophy* of the *bulb*. Dense opacity occasionally appears in the cornea during convalescence, and may go on to ulceration, or clear up perfectly. It may arise with great suddenness, and, when it occurs in the lower half of the cornea, a deep indentation, owing to the pressure of the margin of the lid, is likely to occur.

The appearance of the conjunctiva differs materially in different cases. Its surface may be covered over, not merely with easily detached flakes of lymph, but with a gray, false membrane. More rarely a deep infiltration develops, like that seen in diphtheritic conjunctivitis.

Restlessness, fever, and other constitutional disturbances are sometimes present, and synovitis of the knee and wrists may arise, of the same character as similar complications occurring in adults during gonorrhea.

Conjunctivitis neonatorum does not always follow this course, because the term is made to include affections of the conjunctiva in the new-born other than the types just described—mild catarrhal ophthalmias, hyperemias, and that variety which, according to Noyes, presents the character of a granular, rather than of a purulent, conjunctivitis, and which may continue for weeks without danger of corneal complication.

Occasionally a gonococcal conjunctivitis pursues the course of a simple conjunctival catarrh (Groenouw).

Some hyperemia of the conjunctiva, with a little yellowish discharge in the corners of the eye and slight swelling of the lower lid, is common in babies for a few days after birth, and may be attributed either to uncleanliness or to change of temperature.

**Diagnosis.**—The onset and character of the typical disease, its symptoms and course, render a mistake in regard to its nature practically impossible. Close attention should be given to what at first appears to be a trivial inflammation in the eyes of a new-born child, because a virulent and destructive inflammation may follow with great rapidity. Bacteriologic examination of the secretion is essential, and the findings will determine the true nature of the disease.

**Prognosis.**—This is always grave, but with competent medical attendance, *if the eye is seen while the cornea is still clear*, except in diphtheritic types, in those with inherent malignancy (Randall), or where depreciation of nutrition diminishes the resisting power of the child, the majority of cases should be brought to a successful termination. Hence the attendants of new-born children should be compelled to seek medical advice as soon as conjunctival trouble appears, for delayed or improper treatment means sloughing of the cornea, when no form of medication can do more than relieve the violence of the inflammation, which, when it subsides, leaves the child with sight hopelessly marred, perhaps destroyed. The prognosis of the mild types is favorable.

**Prophylaxis.**—The present high standard of scientific midwifery includes such cautious antisepsis during labor that the risk of contamination is distinctly less than in former times, but still some preventive method should be employed.

The eyes of those children who have passed through a birth-canal known to be infected, or from which the suspicion of infection cannot positively be eliminated prior to birth, should be treated according to the method of Credé, which is as follows: As soon as the head is born, the lids are carefully cleansed, parted, and two drops of a 2 per cent. solution of

nitrate of silver are instilled into each conjunctival sac. Small cold compresses are then laid upon the lids and renewed at suitable intervals. Occasionally severe reaction follows—conjunctival hyperemia or catarrh (the so-called “silver catarrh”), and even hemorrhage from the conjunctiva and corneal haze. Hence it is not necessary to employ this method in all cases. Whenever infection, or the suspicion of infection, can be excluded, milder measures—for example, washing the eyes and flushing them with a saturated boric acid solution—are sufficient. In place of a 2 per cent. solution of nitrate of silver a 1 : 500 solution may be used. Other materials recommended are aqua chlorini (Schmidt-Rimpler), bichlorid of mercury (1 : 5000), carbolic acid (1 per cent.), and the newer silver salts, protargol (5 to 10 per cent.), and argentamin (5 per cent.). With the last-named substance the author has had no experience; protargol has been highly recommended. The hands of the mother, nurse, and child should be searched for sources of infection, and, if gonorrhea is known to exist in the mother, the child should be isolated.

**Treatment.**—If the type is mild, the applications described under simple conjunctivitis are indicated; if severe, three conditions demand attention: The inflammatory swelling of the lids, the state of the conjunctiva, and the corneal complications.

1. During the earlier stages, when the lids are tense and the secretion lacking in its later creamy character, in addition to absolute cleanliness, local application of cold is the most useful agent.

This should be applied in the following manner: Upon a block of ice, square compresses of patent lint are laid, which, in turn, are placed upon the swollen lids and as frequently changed as may be needful to keep up a uniform cold impression. This is far preferable to the use of small bladders containing crushed ice; indeed, the use of ice for infants is not advisable. The length of time occupied with these cold applications must vary according to the severity of the case. Sometimes they may be used almost continuously, and sometimes frequently for periods of half an hour at a time.

On the other hand, hot fomentations are occasionally better than cold, especially when corneal complications exist, or the surface of the conjunctiva is covered with a gray film. These are applied with squares of antiseptic gauze wrung out in carbolyzed water of a temperature of 120° F., and frequently changed.

2. Constant removal of the discharge must be practised.

The lids are to be gently separated, the tenacious secretion wiped away with bits of moistened lint or absorbent cotton, and the conjunctival sac freely irrigated with an antiseptic fluid. For this purpose a saturated solution of boric acid (which is feebly antiseptic, but very cleansing and slightly astringent), or one of corrosive sublimate, a grain to a pint (strong solutions should not be used, because they may injure the corneal epithelium and cause ulceration), may be employed. Special and ingenious forms of lid irrigators have been devised, but are unnecessary. The cleansing process must be repeated at least every hour, day and night, and, if necessary, much more frequently.

The remedies mentioned on page 228 have found favor with some surgeons. In addition to these may be mentioned carbolic acid (0.5 to 2 per cent.), alcohol and bichlorid of mercury solutions, iodoform ointment (4 per cent.), aqua chlorini, cyanuret of mercury (1 : 1500), permanganate of potassium (1 : 5000), employed in copious irrigations, formaldehyd (1 : 3000), and argentamin (2 per cent.) and protargol (0.5 to 1 per cent.). Peroxid of hydrogen acts efficiently in cleansing away the purulent secretion, care being taken that it contains as little free acid as possible. The author has usually secured the best results with boric acid, weak solutions of mercuric chlorid, or permanganate of potassium. The frequent insertion of vaselin beneath the lids is highly commended and should always be practised.

3. The local application of nitrate of silver to the conjunctiva must not be made in the earlier stages before free discharge is established, nor in those cases, no matter what the stage, when the lids are tense and board-like, and the surface

of the conjunctiva covered with a gray film or a false membrane.

When the secretion is free and creamy; when the lids are relaxed; when the conjunctiva is dark red and puckered into papilla-like excrescences, the time for its application has come. Once a day the palpebral conjunctiva and retrotarsal folds should be brushed over with a solution, 10 or 20 grains to the ounce, its surface first having been carefully freed from any adherent discharge, and afterward all excess of the drug washed away with a solution of common salt, and this washing continued until a clean red surface is secured, when the lids may be returned to their proper position, their margins greased with vaselin, and some of the lubricant introduced within the conjunctival cul-de-sac. Ulceration of the cornea does not alter the treatment described, except that pressure upon the globe while manipulating the eye is to be avoided. So long as the discharge is abundant the use of the caustic is indicated.<sup>1</sup> In place of nitrate of silver protargol is recommended by some surgeons (5 to 20 per cent.); also argentamin (3 to 5 per cent.). Largin is inferior to nitrate of silver and protargol in this disease (Stephenson). The author has used protargol very often; mild solutions are not efficient, but strong ones act well, but are not as certain in their results as nitrate of silver.

At the first appearance of corneal haze, a 4-grain solution of atropin is to be dropped into the eye two or three times daily. If, however, a marginal ulcer forms, and danger of perforation is imminent, or even if this has occurred, eserin has been recommended. The use of eserin requires considerable care lest any coexisting hyperemia of the iris be aggravated by the drug, and iritis ensue. For this reason the author prefers not to employ it, although its efficacy in preventing sloughing of the cornea cannot be denied.

Persistent swelling of the conjunctiva is sometimes treated by scarification. Division of the outer commissure to relieve pressure, leeching, and, indeed, any form of treatment followed

<sup>1</sup> Nitrate of silver combines the properties of an astringent, superficial caustic, and germicide.



by decided loss of blood are hardly suited to young infants, although they may be indicated in adults.

If one eye alone is affected, suitable protection for the sound eye should be provided. This may be accomplished by antiseptic bandaging of the uninflamed organ (Buller's shield is difficult of application in infants). The daily use in the unaffected eye of a drop of a 0.2 per cent. solution of lunar caustic has been suggested.

Reduction of the inflammation with cold applications, for which, under the conditions named, hot affusions are substituted; absolute cleanliness; frequent irrigation with antiseptic and slightly astringent solutions; and, at the proper stage, nitrate of silver, will secure the best results.

The attendants must be impressed with the fact that upon their faithful carrying out of directions and upon their unremitting care much, if not all, of the hope of bringing the case to a successful termination depends. The attendants must further be impressed with the contagious nature of the pus; all bits of rag and pledgets of lint used in the treatment must be destroyed, and after each treatment the hands of those engaged must be thoroughly washed and then disinfected with a solution of bichlorid of mercury.

**Gonorrheal conjunctivitis** (*purulent ophthalmia; acute blennorrhoea in adults*) usually can be traced to its source of contagion from an acute gonorrhea or a gleet, by contact with soiled fingers or linen, or from an eye similarly affected.

Purulent conjunctivitis, not gonorrheal in origin, may be caused by the secretion of diphtheritic conjunctivitis, and occasionally by granular lids. Vaginal leukorrhea is not uncommon in young girls, and from this they may inoculate their eyes. It is to be remembered that a catarrhal conjunctivitis, by neglect or injudicious external applications, like poultices, may be aggravated into an inflammation in all particulars resembling gonorrheal conjunctivitis. A few instances of purulent conjunctivitis are on record in which the source of contagion could not be found, and hence the origin has seemed to be spontaneous.

The same micro-organism described in connection with

ophthalmia neonatorum is active in gonorrheal conjunctivitis, the diplococci being found within the cells; later they penetrate the epithelium and enter the lymph-spaces in the sub-conjunctival tissue.

**Symptoms.**—The first symptoms appear from twelve to forty-eight hours after inoculation, and resemble those already recited in connection with the same disease occurring in the newly born.

The vitality of the cornea is in constant danger, and complications in this membrane may arise during the height of the attack, or later, and when convalescence apparently is established. These consist in ulcers, small and large, either central or peripheral; in the latter position they often exist as grooved rings or small clean-cut lesions without infiltration, hidden by the swelling of the surrounding conjunctiva, and very prone to perforate. A more or less dense opacity may follow ulceration or arise independently of this condition.

If perforation occurs, all the phenomena described on page 233 will ensue, and even without perforation, iritis, cyclitis, and disease of the deeper structures of the eye may develop and defeat the possibility of obtaining good vision.

Gonorrheal conjunctivitis reaches its climax in about ten days and then gradually subsides in from one to two months; or it may pass into a chronic type and be one of the forms of *chronic blennorrhœa*, which then consists of a general redness of the palpebral conjunctiva, with hypertrophy of its superficial layers and some thickening of the papillæ.

**Diagnosis.**—This is readily made from the history of the case, and, above all, by an examination of the secretion for the gonococci, which is imperative.

**Prognosis.**—The prognosis is *always* grave, even more so than in conjunctivitis neonatorum. A fully developed case of gonorrheal conjunctivitis rarely recovers without some corneal involvement, and only too often the eye is hopelessly marred.

**Treatment.**—This includes the same principles and practice described in connection with ophthalmia neonatorum (page

235), but requires certain modifications suggested by the adult age of the majority of the cases.

In the beginning, when the inflammatory action is of high degree, a few leeches may be applied to the temple. If the swelling of the lids is so great that their pressure threatens to destroy the cornea, the outer canthus may be divided (canthotomy). This acts in a twofold manner, by relieving pressure and by depleting the engorgement through the loss of blood occasioned by the incision, which should be made with a scalpel, cutting the tissues from without, down to the bone, as far as the margin of the orbit, but leaving the conjunctiva uninjured. Repeated incisions of the hard rim of chemotic conjunctiva which surrounds the cornea will also relieve pressure and is a most useful procedure. In desperate cases some operators (Critchett, Fuchs) have not hesitated to split the lid vertically and stitch the divided portions to the brow, restoring them by a plastic operation after the disease has subsided.

Cold may be applied with compresses in the manner described, or continuously with Leiter's tubes. Under the circumstances already mentioned, hot applications should be substituted.

Local applications include the antiseptic lotions previously given (page 236), in addition to which may be mentioned a drug which the author can highly recommend—viz., permanganate of potassium (1 : 2000) used copiously, a pint at a time, in continuous irrigation, after the manner of Kalt.

At the proper stage nitrate of silver is the best remedy, employed in the manner described on page 237. It is rarely necessary to employ it in a strength greater than 10 to 15 grains to the ounce, but when the granulations of the conjunctiva become exuberant, the mitigated or solid stick at times alone will control the process. What has been said of protargol on page 237 applies with equal force here.

On the appearance of any of the types of *ulceration* atropin drops should be instilled with sufficient frequency to maintain mydriasis and subdue ciliary hyperemia. Eserin has also been recommended, or the combined action of eserine and

atropin, obtained by using the former drug during the day-time and the latter at night. In the majority of instances atropin will secure the best results. Iodoform freely dusted upon the ulcer is of service, and other measures mentioned on page 294 must be considered.

If an ulcer threatens to perforate, paracentesis (page 680) through its floor will diminish the intra-ocular pressure, and may prevent or lessen the extent of prolapse of the iris. A substitute for this operation is the use of the actual cautery, and should be preferred. If perforation has taken place, excision of the prolapsed iris, sometimes recommended, is not without danger, as this procedure may open a way for the entrance of infecting material to the deeper structures of the eye. Hence in a small prolapse, peripherally situated, the vigorous application of eserine (if it does not cause ciliary congestion), or, in one centrally placed, the use of atropin, may secure better results. The final outcome of the case will depend upon the extent of corneal involvement and the ultimate treatment of the remaining leukoma, staphyloma, or shrunken ball will require, according to circumstances, iridectomy, abscission, evisceration, or enucleation.

If the subject of gonorrheal conjunctivitis is a vigorous individual, it has been recommended on good authority to bring the constitution under the influence of mercury, preferably by inunctions, early in the disease when there is high-grade inflammatory swelling. This recommendation seems to the author of doubtful value.

More often the patients are debilitated, and supporting treatment is indicated, namely, quinin, iron, strychnin, and milk-punch, the last especially if there is a tendency to sloughing of the cornea. Any evidences of poor circulation call for digitalis and nux vomica, and these drugs modify favorably the failing nutrition of the cornea. If there is constipation, calomel should be given, and saline laxatives in the morning. The pain, which is often severe, may be allayed with morphin or opium; indeed, the latter drug has a good influence on the sloughing process. It is a mistake, in the serious forms of this disease, to depend alone upon local measures.

The treatment of a *chronic conjunctivitis*, the sequel of an acute attack, depends upon the degree of thickening in the mucous membrane, but is usually best managed by careful exposure of the thickened conjunctiva and applications of nitrate of silver, tannin and glycerin, and the occasional use of the alum or sulphate of copper stick. As a collyrium, boric acid or bichlorid of mercury may be used, or these substituted with sulphate of zinc. Acetate of lead, provided there is no corneal ulceration, has been recommended.

**Prophylaxis.**—Patients suffering from gonorrhea should be warned not only of the great danger of infecting their own



FIG. 88.—Application of Buller's shield.

eyes, but the eyes of those around them. Inasmuch as a very minute quantity of urethral discharge, and even when this is the product of a chronic disease,—gleet, for example,—may produce acute conjunctivitis, these precautions become the more necessary.

As usually one eye alone is affected, it is a matter of great importance to secure the other eye from contact with the secretions. This may be done by sealing it with an antiseptic bandage, the edges of which are made tight by fastening along them strips of gauze painted with flexible collodion, or by the application of Buller's shield. The latter consists of a watch-glass fitted in a square piece of rubber adhesive plaster, which

is carefully applied to the brow, temple, lower margin of the orbit and nose, and should be secured with additional strips to prevent the entrance of discharge.<sup>1</sup> The inner margin should be sealed with collodion, as contamination is most likely to occur at this point, and inefficient application increases, rather than diminishes, the danger.

All the precautions which have been stated in regard to the care of conjunctivitis neonatorum apply with equal and even greater force to the present disease. In a number of instances the surgeon in attendance has been contaminated.

**Metastatic Gonorrheal Conjunctivitis.**—There is one form of conjunctivitis, occasionally seen during gonorrhœa or gleet, which occurs in patients who at the same time have articular affections.

The disease is bilateral, mild in character, and resembles a moderate catarrhal conjunctivitis with some swelling of the mucous membrane. Small ulcers of the cornea may form. Iritis has occasionally followed this inflammation, just as it is seen associated with gonorrheal rheumatism.<sup>2</sup>

The treatment of this affection calls for the same remedies useful in ordinary conjunctivitis.

**Croupous or Pseudomembranous Conjunctivitis** (*Plastic, Membranous Conjunctivitis*).—Of this disease, two varieties may be considered. The *first* is an inflammation of the conjunctiva, characterized by a soft, usually painless swelling of the lids, a membranous exudation upon the conjunctiva, and a scanty, seropurulent discharge.

**Causes.**—The affection in its pure form is rare. It is never found among the new-born, and rarely among grown-up people, the majority of cases occurring in early life—*i. e.*, between first half year and the seventh year.

The contagiousness of the disease has not been established; no definite cause is known, although some relation exists be-

<sup>1</sup> Care should be taken to provide a watch-glass of the ordinary form, not one with a concave center.

<sup>2</sup> Some surgeons apply the name "*gonorrheal ophthalmia*" to this affection, and reserve the term "*gonorrheal conjunctivitis*" for the disease which is caused by a specific urethral discharge.

tween this disorder, scrofula, and eczema. Patients affected may at the same time be suffering from a croupous inflammation of the respiratory tract. Some authors regard the affection as a mild diphtheria. Non-virulent Loeffler bacilli, staphylococci, and diplococci have been found in the secretion.

**Symptoms.**—These begin with an acute conjunctivitis, succeeded by swelling of the lids, which remain soft and pliant, and usually not painful to the touch. In a few days there is a deposit of a characteristic false membrane composed of coagulated fibrin, rather translucent and porcelain-like in appearance, beginning upon the retrotarsal folds, coating the inner surfaces of the lids, but not invading the bulbar conjunctiva. It may readily be removed, and shows beneath a granular and somewhat bleeding surface. It is quickly reproduced. The cornea, except in severe cases, escapes.

Healing takes place in from ten to thirty days, except in those instances where the membrane is formed again and again, and the course of the disease may continue for months and even years, constituting the *recurring form* of pseudo-membranous conjunctivitis.

**Diagnosis.**—The disease may be confounded with conjunctivitis neonatorum and diphtheritic conjunctivitis. From the former it is distinguished by the absence of profuse purulent discharge and the age of the patient; from the latter, by the soft swelling of the lids, the superficial character of the membrane, and absence of virulent Klebs-Loeffler bacilli.

**Treatment.**—This should include the application of ice compresses, frequent removal of the discharge with a solution of chlorid of sodium or chlorate of potash, and later the cautious use of nitrate of silver (Knapp). Other applications recommended are dilute lead-water, chalk-water, iodoform, and quinin.

The *second* variety of membranous conjunctivitis is due to streptococci, is rapid in development, and is associated with swelling of the lids and much discharge, and may quickly destroy the cornea. It occurs in children in connection with measles, scarlet fever, and influenza; but according to Morax may appear independently of febrile complications and may

accompany impetigo. The prognosis is most unfavorable not only to eyesight, but also to life. The disease is often mistaken for diphtheritic conjunctivitis (it is sometimes called *streptococcus diphtheria of the conjunctiva*). Microscopic examination will decide the diagnosis. The treatment already detailed is indicated.

**Diphtheritic Conjunctivitis.**—The deep-seated or necrotic variety of this disease is characterized by a board-like, very painful swelling of the lids, a scanty seropurulent or sanious discharge, and exudation within the layers of the tarsal conjunctiva, which spreads to the ocular conjunctiva, and by pressure destroys the nutrition of the cornea.

**Causes.**—In addition to the Klebs-Loeffler bacilli, which cause the disease, other micro-organisms, for example, streptococci, staphylococci, and non-virulent xerosis bacilli, are usually present in the discharge (Uhthoff). The disease, which is contagious, may originate from a similar case, or arise in the course of a purulent conjunctivitis. It has occurred, though rarely, with conjunctivitis neonatorum. At times it appears in connection with eczema of the face and borders of the lid, and is an occasional accompaniment of some acute illness, like scarlet fever or measles, when the diphtheritic type of the inflammation becomes ingrafted upon the conjunctiva. The disease has been seen during epidemics of diphtheria, and may be part of a process which passes from the nose to the conjunctiva, or may be due to direct inoculation with the diphtheritic poison.

It is commonest between the ages of two and eight, and is unusual in young infants. In certain localities in the south of France and the north of Germany the disease was formerly frequent. It is usually stated that the disease is comparatively rare in America and England; but Sydney Stephenson records a percentage of 1.25. This author regards conjunctival diphtheria and croupous conjunctivitis as one and the same disease.

**Symptoms.**—The patches appear in a *discrete* or *confluent* form; the lids are swollen with a characteristic, painful, board-like hardness. The false membrane is of a dull, grayish



appearance, and is torn off with difficulty. If the process is deep, the subjacent structure is pale, infiltrated, and when cut into may be anemic and lardaceous. If the diphtheric inflammation has been ingrafted upon a case of purulent conjunctivitis, the abundant secretion ceases, or becomes irritating and sanious.

Sloughing of the cornea is almost inevitable in severe cases, and rapid destruction of this membrane may take place in twenty-four hours; even in mild cases ulcers may be expected.

Restlessness, fever, alimentary derangements, and nervous phenomena are usual constitutional disturbances, and the disease may be followed by loss of knee-jerk and paresis of various parts of the body. Albumin may be present in the urine (Stephenson).

This disorder is distinguished from the previous disease by the characteristic board-like infiltration of the lids and the bacteriologic examination, and has nothing in common with the flakes of false membrane sometimes seen in purulent conjunctivitis, from which it is further separated by the character of the discharge and by bacteriologic examination.

**Treatment.**—During the earlier stages cold compresses applied in the manner already described are of doubtful value, because, as corneal involvement is almost inevitable, *hot* affusions are more suitable. The eyes should be frequently cleansed with warm boric acid solution or bichlorid of mercury and atropin drops should be instilled. Iodoform salve (or powder) may be freely applied within the conjunctival sac; indeed, vaselin itself is efficient under these circumstances. Besides the collyria mentioned, solutions of salicylic acid or of carbolic acid in glycerin have found favor. Lemon-juice and citric acid ointment were formerly used.

Internally, quinin, iron, and mercury have been recommended; the first in suppositories, and the last either as calomel or as the bichlorid; of the latter,  $\frac{1}{80}$  to  $\frac{1}{40}$  of a grain may be given hourly to a child from three to six years of age. Of all the remedies named, however, recent experiences demonstrate that the greatest reliance should be placed upon

diphtheria antitoxin, which should be promptly administered exactly as it is in ordinary faucial diphtheria.

The sound eye should be guarded by a bandage or by Buller's shield. Isolation of the patient is necessary, especially if the disease appears in the neighborhood of children who suffer from facial eczema or any form of catarrhal conjunctivitis.

In addition to the deep-seated, necrotic variety of diphtheria of the conjunctiva, the disease, according to Uhthoff, Sourdille, Elschmig, and Morax, may assume a benign aspect and a superficial pseudomembranous form. Why virulent diphtheritic bacilli sometimes cause a superficial and sometimes a deep interstitial type of the affection has not, according to Uhthoff and Coppez, been determined. The former author also describes a simple catarrhal conjunctivitis in association with diphtheritic bacilli.

**Phlyctenular Conjunctivitis** (*Phlyctenular Ophthalmia*; *Scrofulous Ophthalmia*; *Eczema of the Conjunctiva*).—This is a form of inflammation of the conjunctiva, characterized by the appearance of one or more grayish elevations, situated chiefly upon its bulbar portion in the immediate vicinity of the cornea.

**Causes.**—The disease is believed to be of constitutional origin, and its subjects are often strumous and badly nourished children. Errors of diet, unwholesome foods, and the abuse of tea and coffee act as predisposing causes. It often follows the exanthemata, especially measles. Infectious rhinitis is always present, and usually the submaxillary and cervical glands are swollen, and there is eczema of the lip and nares. There is a distinct clinical association between this disease and eczema. It is probable that the active micro-organism is the *staphylococcus pyogenes aureus* or *albus*, which is found beneath the epithelium of the affected conjunctiva.

**Symptoms.**—The disease occurs in a single and a multiple form; the pimples or phlyctenulæ lie near the corneal margin or directly upon it, and are usually from 1 to 3 mm. in diameter.

If the elevations are large, yellow, and contain purulent material, the disease has been called *pustular ophthalmia*.

Under any circumstances it is accompanied by pain, dread of light, injected blood-vessels, and increased lacrimation. The conjunctiva may be transparent, or the disorder associated with a mucopurulent conjunctivitis. After the exanthemata, this association is common.

In the multiple form, numerous minute phlyctenulæ may be scattered over the entire conjunctiva, and are accompanied by decided general red injection, irritation, and photophobia. The disorder subsides in from ten days to two weeks.

**Treatment.**—Locally, mild antiseptic collyria, especially a lotion of boric acid, are applicable. Much irritation calls for the use of atropin drops and the *occasional* instillation of cocain



FIG. 89.—Phlyctenular conjunctivitis (Children's Hospital).

to relieve the photophobia. The eyes may be protected by colored glasses.

After the acute symptoms have subsided, the best results are obtained with the yellow oxid of mercury (one grain to the dram) or with calomel, provided the patient is not taking iodid of potassium, otherwise a reaction between the potassium iodid in the tears and the calomel occurs, with the ultimate formation of double iodids, which are caustics (*calomel conjunctivitis*).

An excellent regulation treatment is a mild course of mercurial laxatives. Simple diet, good air, exercise, and internally quinin, iron, arsenic, and cod-liver oil, complete the therapeutic measures.

Phlyctenular conjunctivitis is so closely allied to phlyctenular keratitis that the separation of the two affections is purely artificial, and this account is a preface to the description of the

more exact disposition and relation of the phlyctenulæ, which appears on page 279.

**Spring Conjunctivitis** (*Frühjahr's Catarrh*, Saemisch; *Phlyctæna Pallida*, Hirschberg).—This is a form of conjunctival disease, usually seen in children, and is characterized by photophobia, stinging pain, considerable mucous secretion, the formation of flat granulations in the conjunctiva, and a hypertrophy of this tissue surrounding the limbus of the cornea.

**Causes.**—Definite information in regard to the cause of this peculiar disease is lacking, although it is probable that a specific micro-organism exists. The characteristic behavior of the disorder has been stated to be its return in the early spring and its subsidence in the fall and winter, although cases are seen in other months of the year, and, moreover, spring and summer exacerbations of ordinary phlyctenular conjunctivitis are marked features.

It is most frequent between the ages of five and fourteen, but occasionally occurs in advanced adult life. It may accompany the disease known as hay-fever. Some writers decline to consider *vernal conjunctivitis* a distinct disease, but look upon it as a hypertrophic form of chronic conjunctivitis. According to Spicer, the granulations consist of epithelium and pedicles of blood-vessels and connective tissue, and are more analogous to fibromas than to papillomas.

**Symptoms.**—The affection begins like an ordinary conjunctivitis and is always bilateral. There are photophobia, more or less mucous secretion, circumscribed pericorneal injection, and the formation, in this region, of small, gray, semitransparent nodules, which swell up and overlap the edge of the cornea.

Three varieties of the disease are described, the *limbus, palpebral*, and *mixed* forms. The conjunctiva of the bulb is injected, that of the lids is slightly thickened, of a dull pale color, as if brushed over with a thin layer of milk (Horner). In severe cases the tarsal conjunctiva is covered with flattened granulations, containing deep furrows between them. In the colored race there is a brownish pigmentation of the scleral base of the hypertrophied masses (Burnett).

The disease is to be distinguished from trachoma by the flattened appearance of the granulations and the absence of infiltration and pannus. Mixed forms of spring catarrh and trachoma have been described (May).

The *prognosis* of the disorder is not unfavorable, except in so far as relapses are concerned, which make its course a long one, often lasting from eight to ten years. Slight opacity of the cornea may result.

**Treatment.**—During the height of the attack the eyes may be protected with dark glasses; weak astringent and antiseptic lotions are applicable. Calomel, yellow oxid of mercury, iodoform ointment, boroglycerid, and strong solutions of bichlorid of mercury are useful. The systematic use of a preparation of suprarenal extract or of adrenalin chlorid (1 : 10,000) is said to be of value (Perret).

The exceedingly troublesome nature of this affection and its constant tendency to recur have led some surgeons to use the actual cautery to destroy the flattened granulations and hypertrophied masses at the limbus of the cornea. Incision of the superficial vessels which run from the outer and inner commissure and empty into the swelling at the limbus has been performed. Electrolysis has been employed, and by some surgeons *brossage* has been advised.

**Follicular Conjunctivitis** (*Follicular Ophthalmia*; *Conjunctivitis Follicularis Simplex*; *Trachoma Folliculare*; *Folliculosis*).—This affection is characterized by the presence of small pinkish prominences in the conjunctiva, for the most part in the retrotarsal folds, and usually arranged in parallel rows. The descriptive term conjunctivitis as applied to this affection is usually not accurate, because, in fact, the signs of inflammation are generally absent.

**Causes.**—The disease arises under the influence of bad hygienic surroundings, especially in pauper schools, where it may appear as an aggravated epidemic, but it is frequently seen in mild form, especially among children during their school years, particularly if they are the subjects of anemia and chlorosis.

Much difference of opinion exists as to whether folliculosis

should be placed in a separate category from granular conjunctivitis, or whether it should be regarded as an early stage of the latter disease. Although transitional forms apparently exist, the evidence, clinically at least, warrants the belief that this affection is distinct from granular lids. Histologically, however, there is no decisive difference between fresh follicles and fresh trachoma bodies. It would seem, as Greeff insists, that folliculosis may arise under the influence of various excipients, and in this sense is a symptom and not a distinct disease.

**Symptoms.**—The children—for it mostly occurs in children and young people—complain of slight dread of light and inability to continue at close work, and inspection reveals numerous round elevations in the conjunctiva, chiefly along the fornix, which are tumefied lymphatic follicles. The color of the follicles varies from nearly white to a decided pink. After their disappearance the conjunctiva regains its natural state. These may not be evident at first if there is associated with the disorder a catarrhal condition of the conjunctiva.

The disorder is to be distinguished from granular lids by observing that the small bodies are neither so large as true granulations nor so highly colored as hypertrophied papillæ; that the mucous membrane is not affected more deeply than the lymphatic follicles; and that cicatricial changes are not present.

The *prognosis* is good in so far as the fate of the mucous membrane is concerned, but the disorder is troublesome and will often last for months, and, under imperfect hygienic surroundings and in crowded asylums, may prove a stubborn endemic.

**Treatment.**—Locally, boric acid, either alone or made up with a few minims of alcohol to one ounce of water, weak bichlorid solutions, and occasional application of iodoform or tannin and glycerin are useful. A salve of one-half grain of sulphate of copper to the dram of vaselin has been highly extolled.

Refractive error, if it exists, should be corrected with appropriate glasses, because ametropia aggravates the disorder.

In stubborn cases, especially in asylums, expression of the swollen follicles with suitable forceps should be performed (see page 678).

**Granular Conjunctivitis** (*Granular Ophthalmia*; *Trachoma*; *Egyptian Ophthalmia*; *Military Ophthalmia*).—This is an inflammation of the conjunctiva in which the membrane loses its smooth surface, owing to the formation of rounded granulations, which, after absorption, leave cicatricial changes. It may be studied under two forms—*acute granulations* and *chronic granulations*.

**Causes.**—*Acute granulations* may arise primarily under the influence of bad hygienic surroundings and develop in institutions where the inmates are crowded together. The disease is propagated by the secretion of one eye coming in contact with another, and perhaps through the atmosphere, and is more likely to attack subjects whose nutrition has been enfeebled by scrofulosis and tuberculosis, but it is not caused by these dyscrasias.

Acute granulations, in the true sense of the term, is not a common disease in this region, and must not be confounded with the violent exacerbations to which the chronic forms of the malady are liable.

*Chronic granulations* may result from the imperfect disappearance of the acute granulations, but much more frequently appear as a primary disorder, and when no such ancestry can be traced.

Certain individuals, especially of lymphatic constitution, are predisposed to chronic granular lids, and although its subjects are often pale and anemic, because they live in badly ventilated homes, there is no proved constitutional disorder which causes the disease, as it may attack those who are in perfect health. This predisposition is not confined to individuals, but includes races, the Jews, the Irish, and the inhabitants of the East, as well as the Indians in our country, being especially liable to the affection, while the negroes are almost exempt. These facts have led a few observers to believe that there must exist in the form of a dyscrasia a predisposition to this disease (Burnett).

The geographic distribution of trachoma has attracted much attention, and it has been found that the dwellers in certain regions of the earth where the climate is damp are readily affected, while an altitude of 1000 feet confers comparative immunity from the disease and facilitates its cure.<sup>1</sup>

The dependence of granular lids upon a special micro-organism (the diplococcus of Sattler, Michel, etc.) has not been established by inoculations, which were unsuccessful, except in half-starved animals (Staderini). Neither has the *trachoma coccus* been identified; indeed, some observers (Mutermilch) deny its existence. A fungus, resembling *microsporon furfur*, active in rabbits, has been described by Nois-zewski; parasitic protozoa have been found by Pfeiffer and suspected by Ridley, and Leber has observed peculiarly formed bodies, but the bacterial or protozoal origin of the disease has not been proved. Its contagious nature, however, is undoubted, especially when the eruption of the granulations is associated with free discharge. Transference of the morbid material to an eye, particularly if its conjunctiva is slightly inflamed, may result not only in a purulent conjunctivitis, but sometimes in a disease like the one from which it came. In this sense the secretion is specific.

**Nature of the Granulations.**—The pathognomonic appearance and essential element of the disease trachoma are the "granulations,"<sup>2</sup> or "trachoma bodies," but the life history and pathologic histology of these bodies and the identity or non-identity of folliculosis and granular lids have not been entirely settled.

Two views have been held—the one, that the trachoma bodies have a special pathologic character; the other that they are derived from the natural lymphatic follicles, and some authors declare that these follicles and their changes originate all the anatomic and clinical qualities of trachoma. Although

<sup>1</sup> According to Burnett, trachoma occurs at an altitude of 4700 feet. Van Millingen denies the influence of altitude and an immunity for certain races.

<sup>2</sup> It should be remembered that the word "granulations" refers to the characteristic feature of trachoma, and not to surface granulations which may form during the course of the disease.



it may not be possible to distinguish in the early stages trachoma bodies from enlarged lymphatic follicles, there is certainly a difference in the nature of the two conditions, and it seems impossible to grant that the follicles of themselves can become trachoma bodies.

Mutermilch doubts the contagious and infectious nature of trachoma, and asserts that any form of conjunctival inflammation may develop into granular disease and that the follicles simply depend upon degrees of lymphoid infiltration.

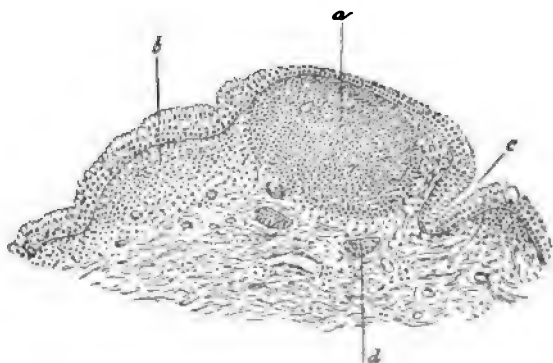


FIG. 90.—Trachoma of the retrotarsal fold: *a*, Follicle; *b*, diffuse infiltration; *c*, Henle's gland with goblet-cells; *d*, lymph-vessel filled with leukocytes ( $\times 30$ ) (Holden).

The following varieties of chronic trachoma have been recognized by systematic writers:

1. *Papillary trachoma*, in which the trachoma bodies or follicles are sparsely present and hidden from view by hypertrophied conjunctival papillæ. The epithelium is thickened, the blood-vessels enlarged, and there is marked increase in the number of lymphoid cells. This form is sometimes spoken of as *chronic trachoma*.

2. *Follicular trachoma*, in which the presence of the "follicles" or trachoma bodies is the chief characteristic. These bodies are round collections of lymphoid cells which may possess an incomplete capsule. Phagocytic cells are found among the leukocytes. Beneath the follicles are dilated lymph-vessels, and blood-vessels may extend into the follicles.

The lymphadenoid tissue surrounding the follicles is infiltrated with leukocytes. Some of the cells of the follicles are discharged or absorbed; others are converted into connective-tissue fibers, which, by their contraction, produce the changes described on page 257. Some authors consider follicular conjunctivitis (page 250) a variety of this type.

In one form, designated by Knapp *non-inflammatory follicular trachoma*, the spawn-like granulations develop in the conjunctiva without evidence of inflammation, and have been regarded as analogous to nasopharyngeal adenoid hypertrophies.

3. *Mixed trachoma*, in which the follicles or bodies lie among hypertrophied and inflamed papillæ, but are not hidden by them. This type is sometimes described as *diffuse* or *complicated trachoma*.

4. *Sclerosing trachoma* (Knapp), in which, after an initial stage of ordinary granulations, leathery (fibrous), flattened excrescences develop in the upper tarsal and retrotarsal conjunctiva.

5. *Cicatricial trachoma*, in which atrophy and scar tissue are manifest—"the end stage of uncured cases" (Knapp).

Although the separation of granular lids into these varieties is convenient from the clinical standpoint, such a separation cannot be maintained on histologic grounds.

**Symptoms** (*Acute Granulations*).—The lids are swollen, the conjunctiva reddened, and the papillæ hypertrophied, and between them are found the non-vascular, roundish "granulations." The dread of light is intense, and, on forcible separation of the lids, scalding tears gush out. The bulbar conjunctiva is injected, superficial vascularity of the cornea arises, and ulceration may appear.

The patient complains of pain in the brow and temple. At first the discharge is scanty, but later mucopurulent or purulent.

The process terminates favorably or runs into the chronic form.

(*Chronic Granulations*).—These often appear without antecedent inflammation, and so insidiously that their real nature

is for a time unknown to the patient. These granulations usually develop in the form of grayish-white, semitransparent bodies, which vary in size according to their stage of development, and which, from fancied resemblances, have been called "sago-grain" or "vesicular" granulations. They may be disseminated or arranged in parallel rows, and have sometimes been likened to the appearance of frog's spawn (follicular trachoma). The granulations are, for the most part, confined to the palpebral conjunctiva, and the upper retrotarsal fold, which is a favorite location, should be well exposed during the examination. Occasionally granulations are found upon the caruncle and semilunar folds.

The mucous membrane is pale or yellowish-red, unevenly

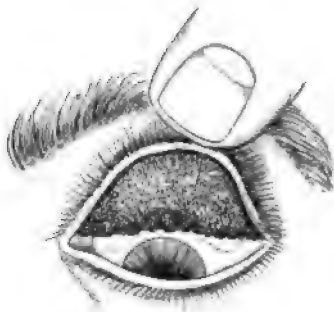


FIG. 91.—Follicular trachoma (Johnson).

rough, and contains the trachoma bodies, or follicles, which have a more or less deep situation and fill up the tissue. If they have not followed an acute process, there are few or no irritative manifestations and little discharge—perhaps only sufficient to glue together the lids. As time goes on the closely packed masses compress the true conjunctival tissue and its circulation, and a superficial vascularity of the cornea may appear. This stage may last for months and be subject to numerous variations.

In the next stage vascularity is increased, the follicles grow larger, soften, and their contents are forced out by the pressure of the surrounding infiltrations, forming, in association with the hypertrophied conjunctival papillæ, red protuberances (mixed

and papillary granulations). This period is associated with strong irritation and mucopurulent or purulent secretion, photophobia, and symptoms of local pain, with fresh development of corneal complications.

During the time of fatty degeneration and softening, which by some authorities is deemed a process of ulceration, fresh follicular (granular) eruptions take place, in turn to go through the same changes which their forerunners have undergone. The mucous membrane now has a flesh-red appearance; it is with difficulty that the "granulations" are distinguished from the papillæ, and indeed they are united with them, forming variously shaped diffuse or isolated protuberances.

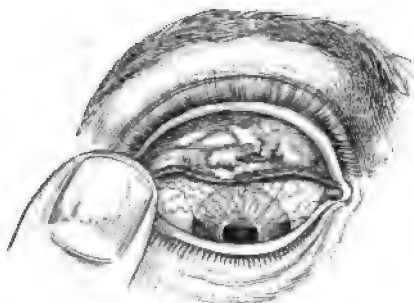


FIG. 92.—Typical granular lid and beginning cicatrization, with pannus (Berry).

In the final stage cicatrization begins, and gray-white scar-lines appear, intersecting the remains of the old "granulations." When these cicatrices lie parallel to the ciliary borders, they present, on eversion of the lid, a typical appearance<sup>1</sup> (Fig. 92).

By a gradual process of cicatrization of the old "granulations" and successive new crops, a chronic induration and diffuse scar tissue results (cicatricial trachoma). This being firmly attached to the tarsus, which itself has undergone softening through a lymphoid infiltration, contracts, and the deformities of the lid and its border, so common in this disease, result. The fibroid induration of the mucous membrane affects

<sup>1</sup> It is convenient thus to divide the disease into three stages, as Raehlmann has done, but it is not always possible to separate sharply each stage by symptoms or appearances peculiar to itself.

all portions, and there may be almost entire obliteration of the conjunctival sulcus, or the membrane may undergo a species of drying up to which the name *xerosis* has been applied. Individuals with granular lids, in the stage of thickening of the mucous membrane have an almost characteristic sleepy look, peering uncertainly through narrowed palpebral fissures, caused by the ptosis-like droop of their indurated eyelids.

**Sequelæ of Granular Lids.**—The most important results of long-standing granular lids are trichiasis, distichiasis, and entropion, conditions already described (page 215), atrophy and shrinking of the conjunctiva from cicatricial changes (page 266), cloudiness and ulceration of the cornea, and *pannus*.

*Pannus* may be looked upon as a form of *vascular keratitis*, which always begins under the upper lid, but which in severe cases may involve the entire cornea. It depends upon the formation of new blood-vessels between the corneal epithelium and Bowman's membrane, associated with collections of round cells. It may be composed of only a few vessels (*pannus tenuis*), or be thick, fleshy (*pannus crassus*), and bulging in appearance. If softening and ulceration occur, the true corneal tissue is invaded.

It is usually taught that pannus is mechanical in origin and is caused by the friction of the granulations. According to Raehlmann, however, it should not be considered as a simple traumatic irritation, but as a follicular process, with the formation of lymphoid infiltration, analogous to the same pathologic condition in the conjunctiva; in short, pannus is to be regarded as a special implantation of the trachoma process in the layers of the cornea. Mutermilch believes that pannus does not depend upon roughness of the conjunctiva, but upon the destruction of living epithelium, and when this is regenerated, the pannus subsides. Extensive and deep ulceration may complicate pannus, which in turn may lead to the development of iritis; or the cornea may become entirely opaque; or, finally, the ulceration may be followed by perforation of this membrane and staphylomatous bulging.

**Diagnosis.**—This presents no difficulties. Acute granula-

tions must be distinguished from purulent conjunctivitis, but the chronic form is made evident by direct inspection of the everted lids, unless the associated swelling of the papillæ is so great as to obscure the "granulations," especially in the forms of papillary trachoma. Hypertrophied conjunctival papillæ, chronic blennorrhœa, or surface granulations must not be mistaken for trachoma. The clinical distinctions existing between trachoma and follicular conjunctivitis have been pointed out.

**Prognosis.**—Under the best circumstances, granular lids, when well established, is a tedious disease, and greatly endangers the vision of the patient. Relapses are frequent, and at any time the disorder is likely to assume an intense inflammatory action analogous to acute granulations. Its contagious character renders the affection especially dangerous in schools or any institution where large numbers of inmates are gathered together. The discharge, even when present in slight degree, is readily conveyed from one subject to another by the careless use of towels and common utensils. Great caution is necessary under such circumstances to prevent a disastrous epidemic.

**Treatment.**—Acute granulations should be managed upon the principles which govern the treatment of acute conjunctivitis generally, and in the earlier stages require soothing remedies rather than strong astringents.

The treatment of chronic granular lids may be divided into three methods: Application of caustics and astringents; operative procedures; and general medication.

*Local applications* include the astringent and caustic preparations which are used to cause absorption of the "granulations," but these should not be of such strength as to produce cicatricial changes more harmful than the original malady. A variety of substances has been employed, and among them four have met with deserved favor—strong solutions of bichlorid of mercury; nitrate of silver; sulphate of copper, either in the form of a crystal or as *lapis divinus*; and boroglycerid.

During the stage of conspicuous lymphoid infiltration and

decided follicular ("granular") eruption, without the presence of purulent discharge, bichlorid of mercury, 1 : 300 or 1 : 500, may be applied to the everted lids with an absorbent cotton mop, from once a day to thrice weekly, according to the amount of reaction produced, the conjunctival cul-de-sac being frequently irrigated during the day with a tepid solution of the same drug (1 : 8000).

In the stage of softening of the granulations and swelling of the conjunctival papillæ, associated with mucopurulent and purulent discharge, nitrate of silver, applied in the same manner and with the same precautions that have been described under Purulent Conjunctivitis, is the best remedy. For this may be substituted protargol and the other newer silver salts.

During the same stage in which strong solutions of bichlorid of mercury have been recommended, or, as it seems to the author, more properly at a somewhat later period, when eruption of new granulations is associated with beginning cicatricial metamorphosis of old crops and their surrounding tissue, but when there is no purulent discharge, sulphate of copper crystal is a standard remedy, and is the one usually recommended for routine treatment. The crystal should be smooth and carefully applied to all portions of the affected areas, especially to the retrotarsal folds, and the treatment followed by washing the surface with cold water. It is a painful remedy, and in sensitive patients there is no objection to cocainizing the eye preparatory to its use.

During the later stages, to hasten absorption of remaining granulations, and, perhaps, to prevent the tendency to xerosis, boroglycerid (30-50 per cent.) is a useful remedy, applied in the usual manner with a mop of cotton. Some surgeons employ this drug in all stages of the disorder.

Among the many remedies which have been tried in this affection the following may be mentioned: Liquid carbolic acid, liquor potassa, betanaphthol, hydrastin, iodoform or aristol (in powder or salve), an ointment of the yellow oxid of mercury, calomel, iodid of silver, ichthargan (0.5-3 per cent.). In mild cases, or after an impression has been made with stronger caustics, a favorite astringent is tannin and glycerin (30-60

grains to the ounce), or the everted lids may be touched with an alum crystal.

During the course of the treatment the affected areas should be frequently irrigated with saturated boric acid, weak bichlorid of mercury or formaldehyd solutions; if much discharge is present, this is imperative. At any time granular lids are liable to take on acute symptoms: increased discharge; exacerbation of pannus, with clouding and ulceration of the cornea; hyperemia of the iris; and acute pain in the brow and temple. Usually strong local applications must be discontinued, and the treatment instituted which is applicable to an acute conjunctivitis. Cold compresses, more suitably substituted by hot applications if there is much corneal disease, frequent cleansing with tepid boric-acid lotion, leeches to the temple, and atropin to keep the pupil dilated, unless this drug itself should aggravate the granular condition, when it may be replaced by hyoscyamin, are then indicated.

*Operative Procedures.*—These include the various methods for removing the granulations by scarification of the conjunctiva; abscission of the granulations; excision of the retrotarsal fold; destroying them, when discrete, by picking them out one by one with a fine needle and emptying their contents, or burning them with a heated wire or galvanocautery; and squeezing them out between the thumb-nails or with specially devised forceps, the two most satisfactory instruments for this purpose being the model of Noyes and the forceps, on the principle of a roller, advocated by Knapp. Exuberant granulations have been scraped away with a small rake or a sharp curet, or removed by rubbing them briskly with a stiff brush, and then applying strong solutions of bichlorid of mercury ("*grattage*") (see chapter on Operation).

Great care must be exercised in practising any of these methods, lest the scar resulting from the operation produce deformities in the lid greater than those likely to be occasioned by the disease; hence if the hot needle or galvanocautery is used, the isolated trachoma bodies alone must be attacked, and the surrounding conjunctiva carefully excluded. Of the methods just enumerated, squeezing out of the granulations



with forceps is the most satisfactory.<sup>1</sup> During its performance, the area of operation should be flooded with tepid bichlorid collyrium and cold compresses afterward applied to subdue inflammatory reaction. Finally mention may be made of the method by electrolysis advocated by Mr. George Lindsay Johnson.

*Treatment of Pannus.*—If this is limited in degree, it requires no special treatment, as it will disappear with the absorption of the granulations. But if it is extensive, and especially if associated with ulceration, special treatment should be directed toward its cure. This includes the local remedies which are appropriate for a vascular keratitis—viz., an antiseptic lotion, and atropin, eserin, or pilocarpin. The first should be used if any tendency to iritis exists and if it does not aggravate the granular condition; the last, when ulcers are present. It is suitably reinforced by the use of atropin at night.

Inveterate pannus without ulceration of the cornea at one time was treated by the production of a violent conjunctivitis, characterized by the formation of a somewhat clinging false membrane, with a 3 per cent. infusion of jequirity painted upon the everted lids. This method was introduced by de Wecker to substitute the old-fashioned inoculation of the conjunctiva with blennorrhœic pus. It has also been advised to apply the same drug in fine powder, a little at a time, exactly upon the portion of the granulations to be absorbed. The author has not been favorably impressed with jequirity, but Masselon and others continue to use it in selected cases, and think it has fallen into undeserved disuse. It has been especially recommended in this country by Cheatham and Sweet.

The operation of *peritomy*, which consists of an excision of a ring of conjunctival tissue surrounding the cornea, has been much practised for the relief of severe pannus. Another method is to scrape away the opaque and vascular areas in the cornea with a small knife (Gruening). If the palpebral fissure becomes contracted by cicatricial changes, or if during

<sup>1</sup> The squeezing operation is more suited to the follicular forms of trachoma than to the other varieties.

inflammatory periods in trachoma, the lids dangerously compress the cornea, the operation of *canthoplasty* affords relief.

*General Medication.*—It is a mistake to depend solely upon local measures for the relief of granular conjunctivitis, for, although the disease has no proved constitutional origin, its subjects give frequent evidence of malnutrition, and are sometimes affected with the scrofulous or tuberculous dyscrasia. Hence in addition to every advantage that fresh air,—if possible, at a high elevation,—good food, and pleasant hygienic surroundings can give them, iron, cod-liver oil, hypophosphite of lime, arsenic, and, in short, a general tonic regimen should be ordered. Suitable attention to the alimentary tract is important.

**Subacute Conjunctivitis** (*Diplobacillus Conjunctivitis*; *Angular Conjunctivitis*).—This is a form of subacute, or at times



FIG. 93.—The diplobacillus of Morax and Axenfeld (from a preparation by Dr. Harold Gifford).

chronic, conjunctivitis, which appears in association with a *diplobacillus* 2 to 3  $\mu$  in length, and 1.5  $\mu$  in breadth, often occurring in chains, first isolated by Morax, and later studied by Axenfeld and others abroad, and by Harold Gifford in this country. According to the last author, the disease in general is insidious in character, frequently beginning gradually and

running a course from six weeks to six months, during which the main symptoms are redness of the edges of the lids, particularly of the angles, and congestion and hypersecretion of the conjunctiva. All cases of subacute conjunctivitis should be examined for the diplobacillus.

The *treatment* comprises the usual measures for conjunctivitis, especially zinc sulphate (0.5–2.5 per cent.) or chlorid of zinc (0.2 per cent.), which is almost a specific.

Occasionally the same bacillus causes a conjunctivitis which is actively acute in the early stages; it has also been found in corneal ulcers.

**Parinaud's conjunctivitis** (*lymphoma of conjunctiva*, Goldzieher) is a rare form of conjunctival affection first described by Parinaud, and attributed by him to infection of animal origin. The disease has been studied in this country by Harold Gifford. Its symptoms are: Swelling of the lids; mucopurulent discharge; large polypoid granulations upon the conjunctiva (appearing a week or two after the onset of the disease); ulcerations between the granulations and involvement of the lymphatic glands on the same side, which may suppurate. Usually one eye only is affected. The disease may last from one to several months. It somewhat resembles acute trachoma, from which it is differentiated by the character of the granulations and the inflammation of the lymphatic glands. Bacteriologic investigations have not demonstrated a specific micro-organism. The *treatment* recommended is antiseptic collyria, nitrate of silver, or sulphate of copper applications, and ablation of the granulations.

**Chronic conjunctivitis** (*chronic ophthalmia*), the result of an acute blennorrhea, has been referred to on page 239. It may be associated with psoriasis (Hutchinson).

As an independent disorder, and assuming more the type of a hyperemia, it is a common disease in elderly people. There are hyperemia, thickening of the papillary layer of the tarsal conjunctiva, swelling of the caruncle, soreness of the edges of the lids, and slight mucopurulent discharge.

**Treatment.**—Cleanliness, with antiseptic lotions, the application of "lapis divinus," the alum crystal, or glycerol of

tannin (gr. x-f 3j), are useful local measures. Aqueous solutions of suprarenal extract (8 per cent.) or adrenalin chlorid (1 : 10,000) will temporarily dissipate the congestion, but the author has not been able to persuade himself that they are curative in their action. The puncta lachrymalia should be examined, and if they are closed, they should be dilated and the lacrimal passages irrigated with an Anel syringe, and the nasal chambers should be carefully treated. Refractive error, which may keep up congestion, requires correction.

**Egyptian and military conjunctivitis** are terms which have at different times been loosely used to describe all forms of conjunctival inflammations occurring in crowded barracks and similar institutions, which assumed an epidemic tendency, pursued a more or less chronic course, and hence included varieties of acute and chronic blennorrhea and mucopurulent conjunctivitis, in addition to those cases which possessed as a fundamental diagnostic symptom "granulations" of the conjunctiva, and which eventuated in the formation of cicatrices.

**Lacrimal conjunctivitis** is really a form of chronic conjunctivitis depending upon obstruction of the lacrimal passages and the frequently associated blepharitis, and in the discharge of which *streptococci* are found. The eyelids are inflamed upon their borders, the cilia gathered in little tufts by the formation of small pustules at their bases, the conjunctiva is injected and tear-soaked, and there is a somewhat gummy discharge. This form of conjunctivitis may be complicated, according to Parinaud, with hypopyon and iridocyclitis.

The *treatment* requires that the lacrimal passages shall be rendered patulous, in addition to the ordinary remedies suitable for chronic conjunctivitis and ulcerated blepharitis.

**Lithiasis conjunctivæ** is a troublesome condition caused by a calcareous degeneration of inspissated secretion in the acini of Meibomian glands. It is more commonly seen in elderly people than in young subjects, especially in such as are rheumatic. On everting the lids, numerous small, yellowish-white concretions will be seen, distinctly gritty to the touch. These act like so many foreign bodies, and produce considerable irritation and pain.

Each concretion should be removed with a fine needle, the conjunctiva having first been rendered insensitive with cocaine.

**Toxic conjunctivitis** is a name suited to those forms of conjunctival inflammation caused by exposure to the influence of certain chemicals, or by the prolonged use of the mydriatics (notably atropin) and the myotics.

**Atropin conjunctivitis** occurs at all ages, but is commonest in old people. Sometimes it will appear after only a few drops of the solution have been used, but usually not until the drug has been employed for a long time. Attempts have been made to explain it by assuming impurities in the drug, the existence of free acid, a septic origin owing to the presence of a fungoid growth, and idiosyncrasy. In a number of instances arthritic history has been obtained (Collins). The disease usually appears in the form of follicular granulations, sometimes associated with much swelling of the lid and eczema of the surrounding tissue.

Eserin, hyoscyamin, duboisin, and homatropin less commonly cause this affection, and the same disorder has been reported as the result of the prolonged use of cocaine.

Conjunctivitis occurs among those who work in anilin dyes, and from chrysophanic acid, when this has been used as an ointment in skin affections. It may follow the sting of flies (Berry) or irritation of caterpillar hairs ("*ophthalmia nodosa*"). The latter disease appears in the form of grayish or yellowish semitranslucent nodules, which have been compared with tubercles, and which may invade the cornea (*keratitis nodosa*) and even the iris.

The *treatment* in general demands the removal of the cause, and in atropin conjunctivitis applications of tannin and glycerin and of the alum crystal are very useful. In some instances the author has found a 1 per cent. solution of creolin of service. A bland ointment for the irritated cutaneous surface is indicated.

**Xerophthalmos** (*atrophy of the conjunctiva*; *xerosis*) is the name employed by systematic writers to describe a dry, lusterless, and shrunken appearance of the conjunctiva, and is recognized under two forms—*parenchymatous* and *epithelial*.

The former type results from cicatricial changes which involve the deep layers of the conjunctiva; the sulcus is obliterated, and the lids, in severe cases, are attached to the eyeball, while the cornea is opaque. The surface of the conjunctiva of the lids is smooth, dry, and almost leathery to the touch. Granular lids, diphtheritic conjunctivitis, pemphigus, and essential shrinking of the conjunctiva are the causes of the disorder.

*Treatment* is of no avail, but some comfort may ensue by instilling glycerin and water or by the local use of an emulsion of cod-liver oil.

In the *epithelial type* the exposed ocular conjunctiva becomes dry and has a lack-luster appearance; cheesy flakes form, and the membrane is greasy and thrown into folds. A short bacillus (*xerosis bacillus*) has been found in the secretion of these cases, but its pathogenic character is doubtful. This form of xerosis sometimes occurs in epidemics, associated with night-blindness, and is seen among people of poor nutrition—for instance, during prolonged fasts—or among those whose eyes have long been exposed to sunlight. It is also one of the symptoms of keratomalacia in infants. According to Stephenson, the disease is not rare. Night-blindness is not always present, but usually there are signs of torpor of the retina, with contraction of the visual fields and reversal of the red and green fields (see also page 549).

The *treatment* demands a nutritious diet, a soothing collyrium, dark glasses, and removal from the surroundings which have caused the difficulty.

**Amyloid disease of the conjunctiva** is a rare disorder in which pale, yellowish masses appear chiefly in its palpebral portion. It has been supposed to arise from granular conjunctivitis, but, according to Raehlmann, the growths are independent of trachoma.

Extirpation is the proper mode of treatment. Their structure is analogous to lymphoid tumors in which a hyaline degeneration may be found, and which in all probability is an antecedent condition. The diagnosis can be made with certainty only by submitting the tissue to the iodine test.

**Conjunctivitis Petrificans.**—In this rare disease, described by Leber in 1895, opaque white spots appear in the inflamed conjunctiva, which are deposits of lime associated with an organic base. This disease may assume a recurring and spreading nature. Excision of the affected areas has been practised.

**Pterygium** is a peculiar, fleshy growth, consisting of hypertrophy of the conjunctiva and subconjunctival tissue. One or both eyes may be affected. Its most usual situation is at the inner side of the eyeball, corresponding to the course of the internal rectus muscle; more rarely it develops at the outer, and very exceptionally at the upper or lower, part. When the fan-shaped expansion arises from the semilunar fold and

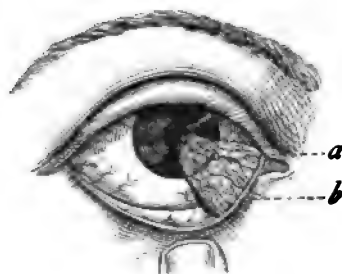


FIG. 94.—Large pseudo-ptyerygium, the result of a lime-burn.

caruncle, it converges as it approaches the cornea, the center of which it rarely passes.

The growth is rare in young subjects, and practically never occurs in children, the average age, according to Fuchs, being about forty-eight, although it often develops at a much earlier period of life. The theory, advanced by Arlt, that ulceration at the margin of the cornea should be regarded as the primary cause of the affection, is no longer tenable. According to Fuchs, pterygium is a development of a pinguecula, and like it, save in exceptional cases, belongs to the so-called senile changes in the eye. As the pterygium develops, the characters of the pinguecula disappear. Individuals exposed to dust, smoke, wind, and heat are predisposed to the formation of pterygia. *Pseudo-ptyerygia* may result from blennorrhœa,

burns, or erosions of the corneal surface, the thickened conjunctiva becoming attached to the corneal lesion.

The *treatment* consists in excision, transplantation, strangulation by means of ligatures, or evulsion (page 675).

**Pinguecula** is a small, yellowish elevation situated in the conjunctiva near the margin of the cornea, and usually at the inner side. It has the appearance of fatty tissue, but is a hyaline degeneration of the connective-tissue fibers of the subconjunctival tissue, and should be regarded, according to Fuchs, as the first stage in the development of a pterygium. It may be excised or destroyed with the actual cautery.

**Abscess of the conjunctiva** is a rare condition, in which a localized area of suppuration appears in the subconjunctival tissues. It may develop in children of greatly depressed nutrition, and is sometimes the sequel of a wound. *Ulcers of the conjunctiva* are occasionally seen.

**Ecchymosis of the Conjunctiva.**—This is an extravasation of blood beneath the conjunctiva scleræ, the meshes of the connective tissue being filled with blood-clot, and occurs as the result of an injury, or from some violent, straining effort—*e. g.*, during a paroxysm of whooping-cough or a convulsive seizure. It may arise without obvious cause, especially in elderly people, and has been seen in young girls at the time of the menstrual epoch. Its occurrence during severe conjunctival inflammations has been described. Recurring subconjunctival hemorrhages are important indications of chronic nephritis and arteriosclerosis. They also occur in diabetes. Ordinarily, subconjunctival hemorrhage will subside by absorption and requires no treatment.

**Chemosis (edema) of the conjunctiva** occurs when the connective-tissue layer is distended with serum, and is often associated with an inflammatory exudate. It is generally a symptom of some other disease—for example, acute conjunctivitis, choroiditis, iritis, or orbital cellulitis. *Angioneurotic edema* of the conjunctiva, with swelling and hyperemia, may appear without any apparent cause, and with marked suddenness. In paralysis of the external straight muscles the overlying conjunctiva is often decidedly edematous, and may be



an early symptom of such an accident. Chemosis of the conjunctiva following the use of iodid of potassium has been reported by the author, and it may succeed a general outbreak of urticaria.

**Treatment.**—The swollen tissues may be incised, and an astringent lotion, like alum, prescribed.

**Emphysema of the conjunctiva** consists in a distention of the connective-tissue spaces with air, and occurs under the same circumstances which occasion this accident when it involves the eyelids.

**Lymphangiectasis of the conjunctiva** is a development of small blisters in the conjunctiva, filled with semitransparent fluid, and usually gathered together in masses. These are situated superficially, and readily move with the conjunctiva over the subjacent tissue. An interference with the natural lymph flow and consequent distention of the lymph-spaces is the probable explanation of their appearance. The affection is said to be most frequent in children, but may occur at any age. Spontaneous disappearance is the common outcome, but, if need be, the small blisters may be incised.

**Syphilis of the Conjunctiva.**—Chancres may develop on the upper or lower cul-de-sac, and even upon the ocular conjunctiva, as primary affections, and not only as extensions from the lids. A few instances of soft chancre have been described.

As manifestations of general syphilis, ulcerated papular syphilids and gumma of the conjunctiva have been recorded. Finally, there is a type of inflammation called *syphilitic conjunctivitis*, which appears as a stubborn catarrh, or in the form of granulations similar to trachoma follicles, developed in an anemic and rather colloid-looking conjunctiva. Its subjects have been cases of pronounced syphilis, and the disease is not amenable to local treatment, but disappears under antisyphilitic remedies.

**Tumors and Cysts of the Conjunctiva.**—As congenital forms, translucent cysts, angiomas, cavernous angiomas, lymphangiomas, dermoid growths (see page 324), and pigment spots have been described. Angiomas may be situated on the palpebral conjunctiva, the bulbar conjunctiva, the fornix, or the

plica. Usually congenital in origin, they may arise in later life. A nevus may be the starting-point of a sarcoma. Pigment spots, after healing of variolous pustules, have been described. *Nævus pigmentosus* also occurs (Wintersteiner) and may give rise to sarcoma.

Cysts are seen in the region of the retrotarsal folds as small, oval, perfectly clear bodies causing no irritation, and arise from epithelial glands (retention cysts). Cysts of the bulbar conjunctiva also occur; they originate in dilated lymph-vessels (lymphangiectasis). Traumatic cysts have been described, due to implantation of epithelium from the skin or cilia.

Among the benign tumors, lipoma, fibroma, osteoma, and

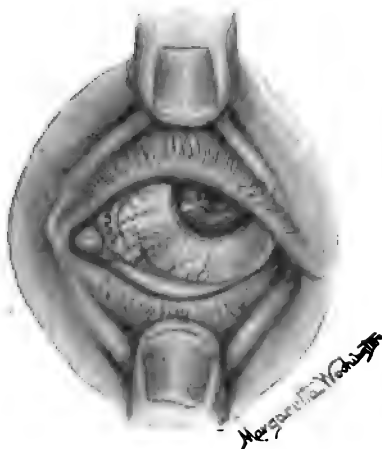


FIG. 95.—Papilloma of the conjunctiva (from a patient in the Philadelphia Hospital).

papilloma have their habitat upon the conjunctiva. Lipomas and lipomatous dermoids are found (Fig. 98) between the superior and the external rectus. Fibromas are either hard or soft, and appear in the form of polypi. Papillomas are either pediculated or sessile, and histologically resemble the structure of the papillæ. They may arise from the conjunctiva or plica. Ordinarily benign, they may undergo carcinomatous degeneration and infiltrate the eyelids (Risley and Shumway). Papillomas have been confounded with bunches of granulation tissue arising from wounds—*e. g.*, after strabis-

mus operations and with angiosarcomas. *Cysticerci*, when they occur, are movable under the conjunctiva, have moderately thick and vascular walls, upon which an opaque white spot is seen, indicating the presence of the receptaculum.

**Treatment.**—Usually the growths described can be readily excised, and the edges of the wound may be united with fine sutures. In simple cysts, cutting away the anterior wall is usually sufficient to cause a cure. Nevi have been treated with applications of ethylate of sodium (Snell).

The malignant growths include epithelioma and sarcoma.

**Epithelioma** may occur as a primary growth upon the ocular



FIG. 96.—Sarcoma of corneoscleral junction (from a patient in the Jefferson College Hospital).

conjunctiva, especially at the limbus corneæ. In the latter situation it appears as a reddish elevation, surrounded by injection. Finally, there are ulceration and implication of the cornea.

The growths are stated to be non-pigmented, but a number of pigmented or melanotic tumors have been removed from this region, which proved to be of epithelial structure. In a large collection of cases Noyes has described other

tumors found in this situation, not conforming to the type of epithelioma, but included under the general term *carcinoma*.

**Sarcoma** of the conjunctiva arises at the limbus, in the form

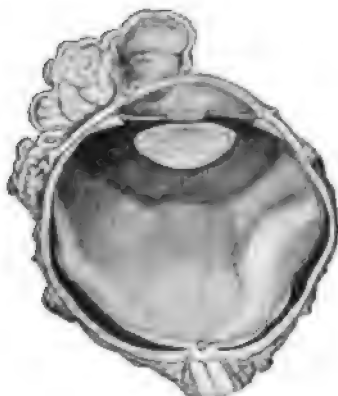


FIG. 97.—Section of eyeball (see Fig. 96) with sarcoma of corneoscleral junction.

of a reddish-white or brownish-black growth, usually overlapping the cornea, but not involving its structure. Both pigmented and unpigmented varieties occur, the former being the more frequent. They may grow rapidly and reach a large



FIG. 98.—Lipomatous dermoid of the conjunctiva: eye turned up and in.



FIG. 99.—Sarcoma of the conjunctiva (from a patient in the Philadelphia Hospital).

size. *Angiosarcomas of the conjunctiva* arise from a proliferation of the adventitia of the blood-vessels, and in their growth, like fibromas, they thrust the epithelial covering in

front of them. They have been mistaken for papillomas. Some epibulbar growths present a markedly alveolar arrangement of their cells (*alveolar sarcomas*), and often the cells are distinctly epithelioid in type (*endotheliomas*).

Removal of these growths by means of knife or scissors is practicable in the early stages without sacrificing the eyeball. In the later stages, or when the extirpation cannot be made complete, enucleation is necessary.

**Leprosy.**—According to Lopez, the chief alterations in the conjunctiva produced by leprosy are anesthesia, inflammation, pterygia, and tubercles. The anesthesia of the conjunctiva probably determines the chronic conjunctivitis, which is common. Pterygia are frequently observed, and are caused by the action of external irritants upon the ocular conjunctiva, which has become insensitive under the influence of the disease.

It is convenient in this place to refer to the effect of *leprosy upon the cornea*, in which the lesions are frequent and varied. The tubercles which form in the conjunctiva are apt to attack the corneoscleral margin, but may involve the cornea exclusively. A late manifestation of the disease is an inflammation of the cornea known as *leprous keratitis*, which somewhat resembles interstitial keratitis.

**Lupus** occurs as a primary disease, or extends to the conjunctiva from the surrounding integument. It appears in the form of red, granular patches placed upon an ulcerated base. As the same microbe is the cause of lupus and tuberculosis, any difference existing in the two diseases when occurring in this situation must rest upon the clinical appearances, the lupus spot showing healing in one direction and active ulceration in another. Those cases in which the disease has spread from the lid to the conjunctiva have especially been classified as lupus.

**Tubercle of the conjunctiva** occurs as a *primary* and as a *secondary* affection.

Primary tuberculosis of the conjunctiva is rare, but a certain number of undoubted instances are upon record in which there was an absence of evidence of tuberculosis elsewhere,

and in which there was no reappearance of the disease locally, or in distant organs, after its removal.

As a secondary affection it has usually appeared in association with nasal and laryngeal tuberculosis.

According to Eyre, who adopts Sadtler's classification, the disease may appear in one or other of the following manifestations: (1) One or more miliary ulcers which usually caseate; (2) grayish or yellowish subconjunctival nodules which resemble the sago granules of trachoma; (3) florid hypertrophied papillæ and rounded, flattened outgrowths of granulation tissue; (4) numerous pedunculated cock's-comb excrescences; (5) a distinctly pediculated tumor. The ulcers have uneven and slightly raised edges, and their floors have yellow or sometimes a lardaceous appearance.

There are thickening of the lids, dark-red swelling of the conjunctiva, considerable discharge, and occasionally tumefaction of the tear-sac. The preauricular and submaxillary lymphatic glands of the same side are enlarged. Pain is not considerable unless the ulceration involves the bulbar conjunctiva and cornea or extends to the lids.

The disease should be distinguished from trachoma, epithelioma, and syphilitic ulceration.

**Diagnosis.**—In any suspected case the real nature of the affection may be decided at once by excising a portion of the diseased tissue, submitting it to microscopic and bacteriologic examination. It is not always possible to demonstrate the presence of tubercle bacilli.

In trachoma the lymph-glands are not involved, and the follicles in acute cases will yield to treatment with sulphate of copper, while in tuberculosis this is ineffectual (Knapp). In the stages of the follicular formation of this disease, the discovery of the bacilli is the only positive differential diagnostic point.

Epithelioma is excluded by the age of the subjects, tuberculosis almost invariably occurring in young people.

**Prognosis.**—This depends upon whether the disease is primary or secondary. In order to prevent general infection, it

is important to eradicate the local lesion. Sight may be destroyed by involvement of the cornea.

**Treatment.**—This demands destruction of all the diseased tissue, and is best accomplished by its removal with a knife, curet, or the galvanocautery. The subsequent treatment should include the use of a collyrium of bichlorid of mercury, and iodoform or aristol powder. Injections of modified tuberculin, used in the manner in which this agent is employed in local chronic tuberculosis (lupus), were at one time suggested.

**Pemphigus of the conjunctiva** is a rare affection, characterized by the formation of bullæ, associated with pain and lachrimation, and after succeeding attacks, degeneration and cicatrization of the conjunctiva. Instead of vesicles on the inflamed area, membranous exudates, grayish-white in color, may form. According to Michel, the disease may be confined to the conjunctiva, or it may attack not only the conjunctiva, but also the mucous membrane of the nose, mouth, and pharynx, and the skin.

The course of the disease, which tends to recur from time to time, is destructive to the nutrition of the conjunctiva, and later to the cornea. The former undergoes cicatricial change, and may grow fast to the ball; the latter becomes opaque and staphylomatous.

Under the name *essential shrinking of the conjunctiva*, a condition of atrophy, contraction, and gradual disappearance of the conjunctival cul-de-sac has been described, during which the free borders of the lids become fixed to the ball and the cornea becomes dry and opaque. This probably is a form of pemphigus, but has also been recorded as an essentially distinct process. According to Pergens, essential shrinking of the conjunctiva may be produced by trachoma, psoriasis, xeroderma pigmentosum, ichthyosis, and lupus.

**Treatment.**—This is practically unavailing. Applications of glycerin and water and other emollients have been employed with the hope of keeping the conjunctiva moist. Rabbit's conjunctiva has been transplanted, but without results. The internal administration of arsenic has been recommended.

**Injuries of the Conjunctiva.**—(a) **Foreign Bodies.**—A small particle of coal, ash, or dust is easily removed if lodged upon the lower portion of the conjunctiva; but if it finds its way beneath the upper lid, and is situated far back under the retrotarsal fold, it may not come into view when the lid is everted, unless the fold is pushed into prominence. If the foreign body is attached to the tissues, it may be necessary to dislodge it with the point of a needle or with a spud. Cocain or holocain will render this operation painless.

(b) **Wounds.**—These may be part of a serious injury involving the lid or deeper structures of the eye; more rarely they occur as simple lacerations, confined usually to the bulbar portion. In suitable cases, after proper cleansing, the lips of the wound should be drawn together with a few sutures.

(c) **Burns.**—These are commonly inflicted with lime (mortar or quicklime), molten metals, powder, and acids, and are especially serious because of the deformity which the subsequent contraction is likely to produce, or on account of the development of a symblepharon (page 214). Ulceration of the cornea, hypopyon, and even panophthalmitis may result. The prognosis of such injuries is always grave.

All foreign substances must be removed at once, and if lime has been the injuring agent, this is best accomplished by forcible irrigation of the conjunctival sac with clean water. Schmidt-Rimpler, however, prefers, under these circumstances, thorough cleansing of the eye with oil introduced with a syringe into the cul-de-sac. For acid burns an alkaline lotion is usually recommended. The subsequent treatment calls for the instillation of olive or castor oil, and atropin drops, to prevent secondary iritis if the cornea is much inflamed; atropin may be incorporated with liquid vaselin and placed in the cul-de-sac.

**Affections of the Caruncle.**—The caruncle and semilunar fold may be swollen in conjunction with a general inflammation of the conjunctiva, but also may undergo localized enlargement and inflammation, to which the name *encanthis* has been applied, and which is subdivided by systematic writers into an *acute*, or *inflammatory*, and a *chronic* variety. The process may go on to the formation of a minute abscess.



Swollen caruncles are commonly found in patients with eye-strain, especially with imperfect amplitude of convergence. The small body is red, elevated, and angry-looking, and injected vessels run from it toward the cornea in the interpalpebral space. This condition might be designated *symptomatic* or *functional encanthis*.

In like manner temporary irritation of the structure is caused by the lodgment upon it of a foreign body, or by the presence of misplaced cilia which rub against it. The caruncle should be carefully examined when patients complain of irritation, lacrimation, and inability to use their eyes with comfort.

The excessive development of the hairs normally placed upon the caruncle is called *trichosis carunculæ*.

A few examples of tumors situated upon and growing from the caruncle have been recorded; in two instances the growth proved to be an adenoma (Prudden and Schirmer). Primary sarcoma (Veasey, Snell) and carcinoma of the caruncle (*malignant encanthis*) have been described. Dermoids, fibroma, lymphangioma, epithelioma, cylindroma, angiosarcoma, and lymphosarcoma have also been reported (V. Berl).

**Treatment.**—Local irritations of this body may be relieved by the direct application of a mild astringent like alum, or soothed by touching it with tincture of opium. Foreign bodies, stiff hairs, and misplaced cilia must be extracted. A tumor is to be removed by the ordinary method of excision.

**Argyria Conjunctivæ** (*Argyrosis*).—Long-continued application of solutions of nitrate of silver or protargol to the conjunctiva may be followed by a brownish discoloration of this membrane. For this reason it is inadvisable to allow patients to use at home even a weak collyrium of this drug. Argyrosis is irremediable. A yellowish-brown discoloration of the conjunctiva, known as *siderosis conjunctivæ*, due to the prolonged use of sulphate of iron, has been reported.

## CHAPTER VII.

### DISEASES OF THE CORNEA.

UNDER the general term *keratitis* are included the divers forms of inflammatory affections of the cornea, to which, according to the type, certain well-marked stages belong; cellular *infiltration* in the layers of the cornea going on either to absorption or to the formation of pus; loss of the substance of the cornea lying over the infiltrated area, and the development of an *ulcer*; loss of the transparency of the superficial corneal layers over an infiltrated area, which has been converted into pus and created an *abscess*, with the final destruction of these layers by future development of the abscess; the appearance of *vessels in the cornea*; and the process of *repair* after loss of substance, or the period of *cicatrizacion*.

Certain associated and subjective symptoms may be present in all forms of corneal inflammation. Among the former the most notable are the congestion of the vessels of the circumcorneal area; involvement of the iris and ciliary body in the severe types of the affection, with the added signs of iritis and the development of pus in the anterior chamber. The subjective symptoms include diminution of vision, pain, photophobia, excessive lacrimation, and blepharospasm.

Although it is customary to divide the many types of corneal inflammation into suitable groups, it is by no means possible to refer the disease in each instance to one or other of these divisions.

**Phlyctenular Keratitis or Keratoconjunctivitis** (*Eczema of the Cornea*).—This disease is characterized by the formation of single or multiple phlyctenules on some portion of the cornea, and is accompanied by dread of light, excessive lacrimation, and blepharospasm.

**Causes.**—The disease is quite constantly seen in strumous subjects, rarely before the first year of life, most frequently in

children before the age of puberty, and less commonly in adults. It often is secondary to phlyctenular conjunctivitis, or is associated with it (page 247). The ordinary symptoms of struma may be present—enlarged lymphatic glands, prominent and swollen lips, and diseases of the joints and bones.

This form of keratitis is in close connection with obstructive (adenoid vegetations) and inflammatory diseases of the nasal passages, and an infectious rhinitis is a constantly associated disorder, which in turn determines an eczema about the nares. Indeed, the clinical association between this disease and eczema is intimate, and eczema of the face and scalp is a frequently accompanying condition. The affection often follows in the wake of measles or other acute exanthemata, and is distinctly under the influence of climate, being aggravated in warm and moist weather.

*Staphylococcus pyogenes aureus* and *albus* is present in the epithelium of the affected regions.

In the belief of some authors, astigmatism bears a relation to its development.

**Symptoms.**—The phlyctenules, which consist in the early stage of minute subepithelial collections of round cells, appear upon the cornea usually at or near the corneoscleral junction. They vary in size from a poppy-seed to a millet-seed; their tops, at first gray, speedily grow yellow, break down, and form superficial ulcers. They are accompanied by decided local congestion, increased lacrimation, and photophobia.

The palpebral conjunctiva, always hyperemic, may remain translucent and bathed in tears, or the disorder is not infrequently accompanied by mucopurulent conjunctivitis.

When the photophobia is severe, the child buries its head deeply in the bed-clothes; the lids are spasmodically closed, rendering inspection of the eye difficult, at times well-nigh impossible. The dread of light and the blepharospasm are probably due to direct irritation of the corneal nerves, as Iwanoff found the cellular infiltration situated along the course of the nerves.

The pustule, when it breaks down, forms the *phlyctenular ulcer*.

## Phlyctenular Keratitis or Keratoconjunctivitis 281

This may remain at its original seat near the margin, or creep toward the center of the cornea (*migratory pustule*), followed by a bundle of thickly crowded blood-vessels, and form a special type of corneal inflammation known as *fascicular keratitis*. The blood-vessels, when the ulcer heals, disappear, but a stripe of opacity remains.

Under the name *marginal keratitis* a variety of this disorder exists, characterized by the development of numerous phlyctenules along the rim of the cornea, giving rise to a process which may cease here, or which, by further invasion, may produce vascular ulcers.

More dangerous than any of the other varieties is the formation of a *single pustule*, just at the corneal border, which speedily ulcerates and is surrounded by a yellow area of infiltration, with a strong tendency to perforate.

If these inflammations recur constantly, the cornea becomes clouded, uneven from loss of epithelium, and covered by numerous superficial vessels, the whole forming the so-called *phlyctenular pannus*.

**Pathology.**—The efflorescence or phlyctenule consists of a collection of lymphoid cells, lying between Bowman's membrane and the epithelium, by the softening of which, as before described, the superficial cells are discharged, and an open, ulcerating surface is left exposed. By further degeneration the entire nodule disappears, and the loss of substance is rapidly replaced with epithelium.

**Diagnosis.**—This presents no difficulties, direct inspection rendering the nature of the disease evident.

**Prognosis.**—The course varies greatly; in mild cases healing takes place with only a slight loss of substance, and the resulting scar is scarcely discernible.

Not so with the severe forms, in which there has been decided loss of substance and a distinct scar tissue remains, or in which deep ulceration with perforation occurs, or where constantly recurring vascular ulceration leaves an uneven and roughened surface. In children of the strumous type, especially if their surroundings are unfavorable, phlyctenular keratitis is exceedingly intractable.

**Treatment.**—In order to make a thorough application of the local remedies the child's head should be taken between the surgeon's knees and the lids separated, while the attendant holds the hands and body; the cornea will usually roll out of sight, but gradually may be coaxed into view. Sometimes a lid-elevator is useful, and a few whiffs of ether or of chloroform may be necessary.

If much secretion is present, boric acid solution is to be employed. Atropin drops should be instilled with sufficient frequency to maintain mydriasis. Cocain, judiciously used, will allay the photophobia, but its continuous application, when corneal ulcers exist, is to be deprecated. Later, an ointment of the yellow oxid of mercury (gr. j-3j), either with or without the addition of atropin, may be employed, or calomel may be dusted into the conjunctival sac, provided no form of iodine is being exhibited (see page 248). The eyes should be protected with goggles, and the child encouraged not to bury its head in the bed-clothes.

Douching the eyes with cold water will subdue the dread of light, and touching the ulcerated external commissure, which almost invariably exists in these cases, with a crystal of blue-stone, as Koller has suggested, helps to relieve the blepharospasm. In severe cases the ulcerated fissure may be incised, or the lids may be forcibly separated. No doubt this acts by stretching or rupturing a few fibers at the commissural angle, and relieves the spasm in the same manner as a similar manipulation is efficacious in fissure of the anus.

The best possible hygienic surroundings must be obtained, with fresh air and wholesome food. Cod-liver oil, iron, quinin, often suitably given with pepsin, and arsenic, are the most acceptable internal remedies.

The urine should be examined in all these cases; and scrupulous attention to the condition of the alimentary canal is an important factor in the treatment.

If rhinitis is present, a powder composed of equal parts of pulverized camphor, boric acid, and subnitrate of bismuth is useful (Augagneur), especially if the parts are thoroughly cleansed with Dobell's solution before its insufflation into the

nasal chambers; or the affected mucous membrane may be painted with compound tincture of benzoin. In obstructive postpharyngeal and nasal affections (hypertrophies, adenoid vegetations) the diseased areas must be treated on the principles of intranasal surgery. A patulous condition of the lacrimal passages should be secured.

In stubborn forms of recurring vascular ulcer and deep ulceration, especially in the fascicular type, the use of the actual cautery in the manner later described is productive of excellent results. In general terms the treatment of severe types of phlyctenular ulcer is the same as that recorded on pages 292-298.

After healing, provided the condition of the cornea permits it, any refractive error should be corrected. There is reason to believe that astigmatism may play some rôle in the production of keratitis in children; hence its correction in patients constitutionally predisposed to this disease, even at a very early age, is a suitable prophylactic measure.

In general terms phlyctenular inflammation of the cornea, which has just been described, is a circumscribed, usually superficial keratitis, and is known under a variety of synonyms,—lymphatic, scrofulous, vesicular, fascicular, and pustular,—and when it appears in adults, assumes the form of a simple corneal infiltration. It furnishes the greatest number of ulcers of the cornea which are found in early life, and also a large group of those ulcers which are of *primary* origin—*i. e.*, where the disease starts in the cornea, the remainder of the group being caused by injury, abscess, depressed nutrition, etc. The entire series is in contrast to *secondary* ulcers—*i. e.*, where the disease follows as the result of a severe inflammation of the conjunctiva—*e. g.*, purulent, diphtheritic, or granular conjunctivitis.

The remaining inflammations of the cornea are divided by systematic writers into *ulcerative* and *non-ulcerative* inflammations.

**Ulcers of the Cornea.**—If the stage of infiltration fails to terminate in absorption and there is destruction of the overlying corneal tissue, an ulcer results. Surrounding the area

of necrotic tissue is a clear space, and beyond this a ring of infiltrating leukocytes which come from the vessels at the edge of the cornea. In favorable cases this necrotic tissue is thrown off, the surrounding cornea clears, the ulcer is covered by a proliferation of the epithelium, and the loss of substance is replaced by connective tissue derived from the fixed cells of the cornea. When the process is progressive, successive layers of the cornea become involved, the iris and ciliary bodies are infiltrated, and hypopyon forms (see page 287). If

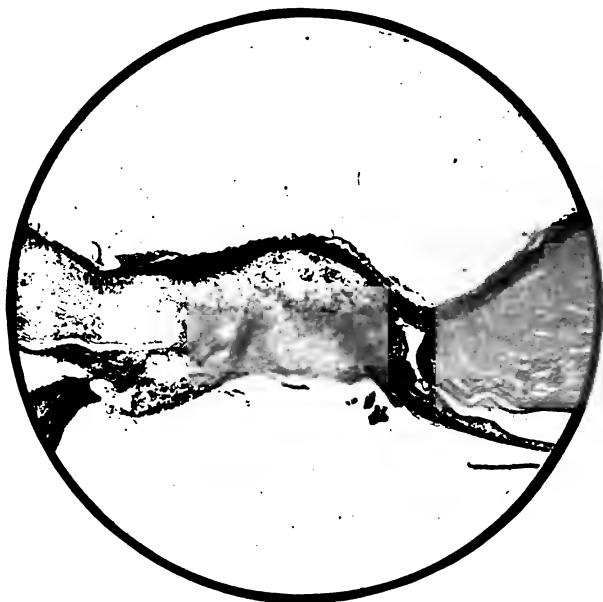


FIG. 100.—Perforating ulcer of the cornea with incarceration of iris (from a photomicrograph).

the ulceration is not checked, the cornea perforates, and inclusion of the iris may result in *staphyloma* (page 299). If the iris does not prolapse, the perforation may be closed by a tissue produced by proliferation of the posterior lining endothelium. Bowman's and Descemet's membranes are never reproduced.

In addition to those which have been described with phlyctenular keratitis, corneal ulcers may be gathered into several groups :

1. **Simple ulcer** appears in the form of a small, superficial, gray lesion, associated with slight pericorneal vascularity, and results from the rupture of a phlyctenule ("pimple ulcer") or from trauma.

An ulcer, which, from its situation, is called *small central ulcer*, appears as a gray or gray-white opacity in the center of the cornea, and is not accompanied with much vascularity or dread of light. The elevation is slightly cone-shaped until the whitish top breaks down into a shallow depression.

Usually single, this form of ulcer may be multiple, and under any circumstances tends to recur. It is seen in young children who have been poorly nourished and are of a strumous habit. While healing generally occurs with promptness, the tendency to recurrence leaves permanent opacity, which, from its central situation, may seriously impair vision. If neglected, and in patients of poor nutrition, this ulcer occasionally forms an abscess of the cornea, or changes its type and develops into the following variety:

2. **Purulent or deep ulcer** consists of an area of yellowish (purulent) infiltration, surrounded by a zone of hazy cornea, round or irregular in shape, centrally excavated, and with a tendency to travel inward toward perforation, but not to extend in a lateral direction. Like all severe types of corneal ulceration, it may be associated with inflammation of the iris and the formation of pus in the anterior chamber; if perforation takes place, an adherent scar or leukoma results.

This ulcer is either *primary* from injury, and sometimes contains a foreign body as its nucleus, or it may be *secondary* to a violent grade of conjunctival inflammation. The subjective symptoms are pain, brow-ache, congestion, and sometimes, though not necessarily, photophobia.

3. **Indolent ulcer** (*absorption ulcer*) occurs under several forms:

- (a) *Shallow central ulcer*, with slightly turbid base, unattended with any considerable pain or photophobia, essentially chronic in its course, and healing finally with a faintly opaque remaining facet (*faceted ulcer*).

- (b) *Excavated or gouged-out ulcer*, often seen in children, most troublesome because it is so rebellious to treatment, has



its seat near the corneal margin. It may be entirely overlooked on account of the absence of congestion, and because in appearance it is a small, punched-out excavation with transparent bottom, and free from any opaque surrounding. The floor of the ulcer loses its translucency when healing is about to take place, and a few vessels of repair pass to its margin.

(c) *Reparative ulcers* are seen when, as occasionally occurs, in the course of the healing of an ordinary corneal ulcer this loses its turbidity and assumes a clear, facet-like appearance. These are similar to the absorption ulcers which occur primarily, and which, unattended with injection and with local symptoms, may none the less extend inward and perforate the cornea.

Indolent ulcers, in general terms, depend upon some failure in the nutrition of the cornea, due to nervous disturbance. They are found in anemic and scrofulous subjects, and are seen in cases of chronic trachoma.

4. **Infecting or Sloughing Ulcer** (*Purulent Keratitis*).—Ulcers unattended by vessels of repair, which spread widely from one border and readily become complicated with hypopyon and iritis, and which are often the result of a trifling injury, usually affect elderly people and those whose nutrition is depressed.

The most important type of these is, the *acute serpiginous or creeping ulcer* of Saemisch. In the beginning a nearly central gray area forms, which ulcerates; its margins are sharp, and one, assuming the form of an elevated curve, is more decidedly opaque or yellow than the others, and is known as the *arc of propagation*. Immediately behind it, the ulcer with its gray floor seems deeper than the portion next to the corneal margin.

The surrounding cornea is opaque, and the lesion spreads rapidly, at the same time growing deeper; iritis, iridocyclitis, and hypopyon ensue, and perforation and extensive sloughing of the cornea are likely to occur. Usually the patient complains of severe brow pain, and the eye is intensely tender. Vision is reduced to mere light perception. In other cases, while the local lesion is severe, the subjective symptoms of inflammation are almost absent.

*Hypopyon*, to which reference has just been made, may be seen with both small and large ulcers, and consists of a collection of pus in the anterior chamber, varying in extent from a mere line to a quantity which well-nigh fills the chamber.

This appears as a yellow mass at the bottom of the anterior chamber, and is bounded above by a horizontal margin. If the collection is fluid, its position will shift with movements of the head; if it is tenacious, no movement can be observed. The pus is caused by an aggregation of leukocytes derived from the vessels about the periphery of the cornea and from those in the inflamed ciliary body and iris, the endothelium of which is cast off. In other words, the pus in hypopyon does not come from the cornea. Sometimes Descemet's membrane is ruptured, without perforation of the cornea, and then the

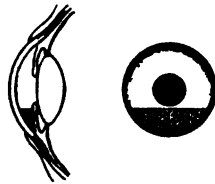


FIG. 101.—Hypopyon, or a collection of pus in the anterior chamber.

pus in the cornea and in the anterior chamber are in direct connection.

The combination of ulcer of the cornea and pus in the anterior chamber has received the name *hypopyon-keratitis*, which generally is limited to the type described as infective or creeping ulcer.

*Causes of Infective or Sloughing Ulcers.*—The investigations of Uththoff and Axenfeld have demonstrated that—(1) Typical serpiginous ulcer of the cornea with hypopyon is practically always caused by the *pneumococcus* (Fraenkel-Weichselbaum capsulated diplococcus); this micro-organism may frequently be found in these ulcers in almost pure cultures. (2) Sloughing ulcers not typically serpiginous are caused by infection with *staphylococci*, *streptococci*, and by *mixed infection*. Occasionally pneumococci originate ulcers which are not characteristically creeping. (3) About 1 per cent. of the sloughing

varieties of keratitis are due to a schizomycetal infection—the *aspergillus fumigatus* (keratomycosis aspergillina). This ulcer has a dry appearance and has been compared to a greased spot. A crust appears with its surface elevated above the surrounding cornea, which is markedly infiltrated. Hypopyon and iritis may be present.

The various micro-organisms come from the conjunctiva, the ciliary borders, the nares, and the lacrimal passages. An injury to the cornea from a chip of stone, a chestnut-burr, beard of wheat, or the like, may become infected, and is the starting-point of this dangerous form of corneal ulceration. Fungus-infection of the cornea, as a rule, starts in an injury (Uhthoff). Typical serpent ulcer is rare in children, whose corneas appear to withstand pneumococcal infection.<sup>1</sup>

**5. Abscess of the cornea** consists of a purulent infiltration in the deeper layers of this membrane, over the center of which, in the early stages, the epithelium is unbroken and prominent, but later, discolored and slightly sunken.

The corneal zone immediately surrounding it is hazy. The margins of the collection are thicker and more prominent than its middle; pus is seen in the anterior chamber; the aqueous humor is turbid, and the iris inflamed.

The subjective symptoms of severe corneal disease are commonly present, but, as with sloughing ulcers, these indications may be absent.

If the abscess is deep, the process may terminate without rupture of the upper layers and the formation of an open lesion, but generally it grows more yellow, notches laterally, bulges forward, and finally bursts, leaving a more or less ragged ulcer covered with tenacious pus, and pursuing a course

<sup>1</sup> According to Uhthoff (*Ueber die neueren Fortschritte der Bakteriologie auf dem Gebiete der Conjunctivitis und der Keratitis des Menschen*, Halle, A. S., 1898), the following micro-organisms have thus far been described as exciters of keratitis in human beings: (1) The Fraenkel-Weichselbaum capsulated diplococcus; (2) streptococci; (3) staphylococci; (4) Pfeiffer's capsulated bacillus; (5) bacillus pyogenes foetidus; (6) bacterium coli; (7) bacillus pyocyaneus; (8) diplobacillus; (9) ozena bacillus; (10) aspergillus fumigatus; (11) tubercle bacillus; (12) lepra bacillus. In addition, other varieties of bacilli have been described which were not again found, or which could not be identified.

similar to or identical with that described under sloughing or infecting ulcer, of which, indeed, abscess is the first stage. It will hence be seen that abscess of the cornea, according to its stage, may belong to the non-ulcerative or ulcerative lesions of the cornea.

*Causes.*—Abscess of the cornea results from an inoculation of the affected area with the pathogenic micro-organisms which are the cause of suppuration, these having gained entrance through an abrasion in the epithelial cells. As already stated, simple ulcers, through neglect, may form abscesses; and they follow slight traumas when the latter become infected, especially by unhealthy lacrimal secretion, and are seen in association with violent types of conjunctival inflammation. A certain number of cases have been ascribed to cold; in still others no definite cause can be ascertained.

A variety of abscess of the cornea, non-inflammatory in character, without any healing tendency, and with an entire absence of subjective symptoms, has been described as occurring in scrofulous children under eight years of age. The character of the disease and the constitution of its subjects have led some to consider it a form of *tuberculosis of the cornea*.

Most violent forms of *suppurative keratitis* occur during the convalescent stages of small-pox, though pustules rarely form upon the cornea. Abscess of the cornea occasionally accompanies scarlet fever, measles, typhoid and typhus fever, and in these cases must be regarded as metastatic, the pathogenic material having been conveyed through the blood, and not as coming from without, as in the more usual examples.

6. *Ulcus rodens* is the name applied by Mooren to a *creeping ulcer* which begins at the upper edge of the cornea as a superficial lesion, separated from the healthy portion by a gray, opaque rim, which is undermined. Although vessels may pass to it and cicatrization apparently begin, it relapses quickly and progresses forward, until the whole cornea has been traversed and sight is destroyed. The cornea is not perforated in this disease, which is a rare form, sometimes bilateral,

attacking adult and depressed subjects. It is called by Nettleship *chronic serpiginous ulcer* and *Mooren's ulcer*.

7. **Circular ulcer** (*marginal ring ulcer, annular ulcer*) occurs in the form of a deep groove at the corneal margin, unaccompanied by much infiltration, which gradually progresses until it may entirely girdle the cornea and cut it off from its nutrition. Photophobia, injection, lacrimation, and other irritative symptoms are not prominent, but perforation of the cornea and prolapse of the iris are common. The disease is seen in debilitated subjects.

Another variety of *ring ulcer* is formed as the result of a *marginal phlyctenular keratitis* (page 281), probably by the coalescence of a number of small foci. Ring ulcers are also seen in catarrhal and purulent conjunctivitis, and in the latter condition may prove especially dangerous if they are hidden by the chemotic conjunctiva.

8. **Dendriform ulcers** (*keratitis dendritica; ulcerans mycotica; furrow-keratitis; k ratite ulc reuse en sillons  toil s*) are a form of keratitis probably dependent upon a special micro-organism, and appear in branch-like ramifications, having a superficial situation, with slight knob-like swellings at the end of the branches. The inflammation manifests itself in two forms.

In one, from the beginning, the symptoms include photophobia, lacrimation, strong bulbar injection, swelling of the upper lids, and absence of the epithelium over the furrow-formed ramifications—an implantation of the process in the deeper corneal layers.

In the other, the disease assumes a subacute or torpid character, with practical absence of severe irritative symptoms and loss of the covering epithelium—a limitation of the lesion to the superficial layer. In the first form the opacity is confined to the axis of the furrows; in the second, to the border. After healing, the scars have the same general configuration which was present during the stage of ulceration. The disease is rare and occurs in both sexes.

The *cause*, further than its probable mycotic nature, is unknown. Fuchs thinks some cases may arise from febrile

herpes of the cornea (page 304), by the increase and coalescence of the small blebs. Malaria originates a keratitis in which the lesion consists of a peculiar, narrow, serpiginous, superficial ulcer, with lateral offshoots, like the skeleton of veins in a lanceolate leaf, usually accompanied with photophobia and lacrimation, and sometimes ushered in with severe supra-orbital neuralgia (Kipp).

**9. Exhaustion ulcer (*keratomalacia*)** may appear as an extensive ulceration in the center of the cornea, or as a ring abscess at its circumference. The tissue speedily is converted into a slough, which drops out, and an extensive perforation results.

In other instances the sequel is described as a species of *atrophy of the cornea*, which is converted into a whitish, flattened plate (Schmidt-Rimpler).

One or both corneæ may be affected, and the usual cause is exhaustion after acute illness or after prolonged diarrhea or dysentery. A similar softening and sloughing of the cornea may be the result of ophthalmia neonatorum (page 233), or cataract operations which have become septic, and they are seen in a perfect type in xerotic keratitis (page 302).

**Prognosis of Ulcers of the Cornea.**—This necessarily depends upon the character and situation of the corneal lesion, but even in the mildest forms some corneal opacity or irregularity of the corneal epithelium will remain (see page 298). If bacteriologic investigation should reveal the presence in the ulcerated area of pneumococci or of a mixed infection, the prognosis is serious, and at once the measures described in paragraph (δ), page 294, should be instituted in the hope that the spread of infection may be prevented. In severe forms of suppurative keratitis the prognosis is most unfavorable, although active treatment will sometimes be followed by surprisingly good results.

**Treatment of Ulcers of the Cornea.**—It is not possible to lay down definite rules for the treatment of all forms of corneal ulceration—this must be governed by the exigencies of each case; but certain principles are common to the various types.

*Acute Stage: Pain and Photophobia.*—These should be re-

lieved by the plans already suggested in treating phlyctenular keratitis. In mild cases atropin, a lotion of boric acid, and dark glasses will usually suffice. The use of blisters and setons, recommended in chronic cases, is seldom required, but a leech to the temple in sthenic types may be needed.

Cocain will relieve photophobia temporarily, but its *continuous use in corneal ulceration is positively harmful*. Holocain, on the other hand, is of distinct value, as pointed out by Hasket Derby, especially when applied directly to the ulcerated surface. If a corneal ulcer is accompanied by much dread of light, the methods described under phlyctenular keratitis may be employed.

Whenever corneal ulceration is accompanied by conjunctivitis, the inner surfaces of the lids should be brushed over with a weak solution of nitrate of silver (2-5 grains to the ounce) or protargol (5-10 per cent.), and the cul-de-sac carefully cleansed with a boric acid solution, a collyrium of bichlorid of mercury (1 : 8000) or formaldehyd (1 : 5000), as often as necessary to free the eye from accumulated secretion.

*Subacute and Torpid Stage.*—After the subsidence of the acute symptoms, or when the ulcer from the beginning is unaccompanied by these, local stimulation should be practised. This is best done with an ointment of the yellow oxid of mercury prepared by the following formula :

Yellow oxid of mercury . . . . .	1 grain
Sulphate of atropin . . . . .	$\frac{1}{4}$ "
Vaselin . . . . .	1 dram.

A small portion to be introduced between the lids night and morning.

The atropin maintains the mydriasis and at the same time is sedative. When these actions are no longer needed, the atropin may be omitted from the salve, and the mercurial compound alone employed. Finely powdered calomel dusted into the eye is also of excellent repute. In like manner iodoform or aristol, in salve or powder, may be tried. Eserin has been recommended instead of atropin, in small sluggish ulcers unattended by active symptoms.

*Deep and Sloughing Ulcers.*—It was a universal and is still a common practice to instil a solution of *atropin*, because of

its anodyne effect and because it lessens the liability to iritis. The solution should be sterile, as otherwise a simple ulcer may be infected and pass into a sloughing condition.

In some cases *eserin* is employed, because it stops the migration of white blood-corpuscles, or promotes absorption through dilatation of the ciliary vessels, or limits the sloughing process. Furthermore, abnormal intra-ocular tension is lowered by the action of the drug. The strength of the solution may be from  $\frac{1}{4}$  to 1 grain to the ounce, the latter being unnecessarily active in most cases. One or two drops of the *eserin* solution should be instilled from three to six times daily; and as, under its influence, congestion of the ciliary body and iris may ensue, as well as brow-pain, these complications should be counteracted by using a few drops of the atropin lotion at night. Deep ulcers near the margin are those most suited for the *eserin* treatment. The author, after considerable experience, is persuaded that *eserin* in corneal ulceration has a very limited sphere, and that atropin is almost invariably the better drug.

Pain is relieved and the process of repair encouraged by the frequent application of *hot compresses* (see page 236). Hot water (150° F.) dropped directly upon the ulcer is recommended by Lippincott. The cul-de-sac and lacrimal passages must be irrigated frequently with *antiseptic collyria*—a saturated solution of boric acid, bichlorid of mercury (1 : 10,000), aqua chlorini, or formaldehyd (1 : 5000). Protargol is also useful under these conditions.

1. *Impending Perforation*.—When perforation of the cornea is liable to occur by extension of the ulcer, a *dry antiseptic compressing bandage* should be applied, removed when the necessary local applications are made, and again reapplied. Long-continued use of the bandage may be followed by eczema of the lids. This should be treated by dusting the parts with calomel. Catarrh of the conjunctiva and dacryocystitis contraindicate the use of the bandage unless the danger of perforation is imminent.

If bulging forward of the floor of the ulcer indicates that perforation threatens, the intra-ocular tension should be lessened by *paracentesis of the cornea*. This operation is described



on page 680. It may be necessary to repeat the operation on several days. Intense pain will often be thus speedily relieved and healing rapidly result.

2. *The Spread of Local Infection.*—If, in spite of such treatment, the corneal ulcer continues to spread, either in the form of a lesion creeping across the face of the cornea or by passing inward through its layers, the process must be stopped by one of several means: (1) Scraping with a curet; (2) the direct application of a suitable chemical which combines the properties of a germicide and a caustic; (3) the actual cautery.

(a) The ulcer may be curetted with a sharp spoon (under a boric-acid spray—de Wecker), all the sloughed material removed, the edges penciled with a sublimate solution (1:2000), iodoform dusted upon its surface, and a dry sterile bandage applied. Mules advises softened iodoform wafers.

(b) The chemical substances commonly employed are nitrate of silver, carbolic acid, tincture of iodine, and formaldehyd. The first, in the strength of 10 to 20 grains to the ounce, is applied directly to the seat of ulceration (care being taken to avoid the surrounding cornea) by means of a probe on which has been twisted a thin band of absorbing cotton, or the point of a pencil of lunar caustic may be gently pressed against the sloughing tissue. Carbolic acid (liquid) may be employed in the same manner as the silver solution; or tincture of iodine, or a caustic solution of formaldehyd (1:50). Of these substances, iodine has given the author the greatest satisfaction.

(c) The actual cautery may be either a small Paquelin or galvanocautery; when neither of these is at hand, a knitting-needle or platinum probe, heated red hot in the flame of a Bunsen burner, will suffice. The edge and floor of the ulcer should be gently but thoroughly burned. Usually one cauterization is sufficient, but in the event of failure to destroy all the sloughing material, the operation should be repeated on the following day (see also page 681). Cocain renders the operation painless, but there is no objection to general anesthesia in nervous patients.

If the surgeon is careful to touch only those portions involved in the ulcerated process, the resulting scar will not be

greater than would have been the case had the ulcer secured cicatrization without such treatment. Fluorescein will show the extent of the ulcer and mark out the area to be cauterized.

The actual cautery is indicated in all sloughing ulcers which fail to show improvement after milder measures have been tried, and in torpid or relapsing ulcers, without much reaction, where a decided stimulant is needed. In certain types of infecting ulcers, of serpiginous character, typified by Saemisch's ulcer, and also in annular ulcer and furrow keratitis, where the apparent local infection is less marked, the actual cautery is the most potent agent to arrest the process. In rodent ulcer it is one of the few means that are at all efficacious, and is indicated in cases of fascicular keratitis.

*Abscess and Hypopyon.*—The pus should be evacuated. If the abscess is unbroken, its anterior wall may be incised with a delicate knife, and the subsequent treatment conducted on the principles laid down for sloughing ulcers. If the abscess has burst and is complicated with hypopyon, the latter may be encouraged to absorption by paracentesis of the cornea in its lower portion, or by the more formal procedure of Saemisch, in which a section is made directly through the diseased area (page 681). Iodoform introduced into the anterior chamber has been recommended under these circumstances by Haab and other surgeons. The author has had no experience with the method.

The use of the actual cautery and the antiseptic treatment of ulcers have to a great degree replaced the operation of Saemisch, and in many instances absorption of the products of a hypopyon keratitis will follow the non-operative treatment already described.

*Perforation.*—If perforation occurs, the vigorous use of atropin or eserine, according as the lesion has a central or peripheral situation, aided by gentle efforts at *reposition* with a probe, a compressing bandage, and rest in the recumbent posture are the first measures.

In the event of failure, or in any event, if the prolapse is a large one, the iris may be drawn forward through the aperture and excised close to the cornea. After excision, the

aperture may be covered with a conjunctival flap taken from the bulbar conjunctiva, twice as large as the original opening, into which it is gently inserted with a probe. A firm compressing bandage, not to be disturbed for three days, is then applied. This method, which can be recommended, is said by its author, Gamo Pinto, to secure a flat cicatrix, often without any attachment of the iris, although anterior synechia usually results even from the smallest perforation. Sometimes after excision of a prolapsed iris the wound may be closed with a delicate corneal suture. If the prolapse has been large, a more or less complete staphyloma will follow in spite of vigorous bandaging and the use of eserine or atropine.

*Résumé of the Local Measures.*—The most useful antiseptics during corneal ulceration are boric acid (saturated solution), bichlorid of mercury (1 : 8000 or 1 : 10,000), formaldehyd (1 : 5000), and iodoform in salve or powder. For the last drug may be substituted iodol and aristol, which, however, do not seem to surpass it in beneficial results. Chlorin water, in half strength, is much employed by some surgeons.

Of the local measures to stimulate healing in sluggish ulcers or to hasten the process of repair, the yellow oxid of mercury in salve (Pagenstecher's salve) is most commonly employed. This remedy may be replaced by an ointment of iodid of potassium, iodol, aristol, or iodoform. Euphen (in salve or powder) and dermatol have not acted favorably, according to the author's experience, in any stage of corneal ulceration.

The anilin dyes, in the form of blue and yellow pyoktanin, are useless and sometimes harmful. Subconjunctival injections, formerly of corrosive sublimate, but now of physiologic salt solution, have been recommended, and sometimes are most efficient.

The indications for a mydriatic or a myotic have been given. If for any reason (idiosyncrasy) atropine is not tolerated, mydriasis may be maintained with hyoscyamine or daturin; and if eserine creates irritation, pilocarpine in double the strength may be tried. It is important to remember that cocaine has no place in the treatment of corneal ulcers, save only as a temporary remedy—for example, to produce anesthesia prepara-

tory to operation or to remove a foreign body. Its continued use tends to aggravate the ulceration. As already noted, holocain is most valuable. For prolonged anesthesia dionin (5 per cent.) has been employed; the author has not been favorably impressed with this remedy.

Of the methods described to check infecting ulcers, curetting, iodoform, and the bandage, and touching with nitrate of silver or iodine are the most generally applicable, unless the conditions are present which demand the actual cautery.

*Associated Conditions.*—The treatment of conjunctivitis complicating ulcer of the cornea in no wise differs from that suited to ordinary cases. An ulcer should always be carefully examined for the presence of a *foreign body*, which may be covered by a small slough, while *misplaced cilia* are fruitful sources of corneal irritation and may hinder the prompt healing of ulcers. They should be removed with epilating forceps or destroyed by galvanopuncture.

The *lacrimal passages* should be explored, and if strictured, rendered patent, while irrigation of the lacrimal canal with a 4 per cent. solution of boric acid, or 1 : 8000 solution of bichlorid of mercury, or 5 to 10 per cent. solution of protargol, is of material aid in the treatment of infecting ulcers, because this passage is commonly the seat of unhealthy secretion. At the same time the nasopharynx needs exploration and treatment of diseased conditions.

The *teeth* should always be examined, and if faulty, the case turned over to a competent dentist. The frequent relation of carious teeth to corneal ulceration is well established, and the irritation of a new dentition in young children has been found to be the cause of abscess or ulcer of the cornea. In brief, the entire *cephalic mucous membrane* (Harrison Allen) should be explored, because, in one or other of its component parts, it may be the seat of disease, which, even if it is not the cause of the coexisting corneal ulceration, is none the less responsible for retardation in the healing process.

*Constitutional Treatment.*—Hygiene, diet, and judicious internal medication are of paramount importance. The patient should not be secluded in a dark room, but, with eyes properly

protected with goggles, go out into the fresh air every day. The diet must be nutritious and easily digested; tea, coffee, candies, and pastries are to be forbidden.

If struma is present, cod-liver oil, lactophosphate of lime, and iodid of iron or syrup of hydriodic acid are indicated; anemia is best treated with the tincture of the chlorid of iron or with the carbonate of iron; any suspicion of malaria requires the use of quinin and arsenic. The syphilitic taint, which may be present without being the direct cause of the ulcer, indicates the iodids, and mercury, especially in the form of the bichlorid. As gout has been shown to be the cause of some corneal ulcers, this, as well as the rheumatic dyscrasia, must be searched for, not alone as an active manifestation, but also as a hereditary disease, and suitable remedies exhibited: citrate of lithium, mineral waters, iodids, colchicum, salicylic acid, salol, etc.

A very strict inquiry into the condition of the alimentary canal should never be forgotten, as this may not be in a condition properly to receive the tonics which are indicated. In children, calomel is a useful laxative; in older patients, the salines and saline waters are often necessary.

The urine should be carefully examined for albumin and sugar, and for the products which indicate imperfect assimilation.

A very important element in the successful management of cases of sloughing ulcers, especially in subjects of depressed nutrition, is the maintenance of proper circulation. This is best secured by the exhibition of brandy or whisky in milk, and of strychnin or digitalis as a vasomotor or cardiac tonic. Severe pain may be alleviated by opium or morphin in suitable cases; the drug also has a favorable influence upon the ulceration.

**Results of Corneal Ulceration.**—Opacities more or less permanent follow all ulcerations of the cornea. If the opacity is slight, it is spoken of as a *nebula* or *macula*; if dense, as a *leukoma*. An old corneal macula possesses a good reflecting surface, which serves to distinguish it, as Haab points out, from a recent inflammatory infiltration, which has a dull surface.

When perforation has followed ulceration and the iris has remained entangled in the aperture, the attachment is called an *anterior synechia*; the corneal scar to which the iris is fastened receives the name *adherent leukoma* (Fig. 102). An



eye thus afflicted may become quiet and retain, either with or without operative interference, useful vision ; but may also be a continual source of annoyance, subject to recurring attacks of inflammation, and may originate sympathetic irritation in the fellow eye.

The mechanism of the development of staphyloma is, briefly, as follows: A perforation takes place, and the iris falls

forward and attaches itself to the opening, or protrudes through it, becoming fixed there by the lymph thrown out in the process of repair. The scar tissue which remains fails to withstand the intra-ocular tension, and that portion of the cornea is pushed forward beyond its normal limits, forming a pouch-like deformity.

The protrusion may flatten down, and under the influence of fresh inflammation bulge forward again, or may extend between the palpebral fissures and prevent the lids from closing (consult Fig. 103). Staphylomas, the result of ulceration, are more or less opaque, because they represent the scar tissue which has formed after the rupture of the membrane. Corneal



FIG. 103.—Complete staphyloma of the cornea.

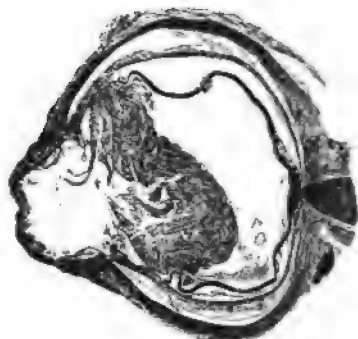


FIG. 104.—Section of an eyeball with complete staphyloma of the cornea.

staphylomas, which are not opaque and have not formed under the influence of an inflammation, also occur, and will presently be described. Thick corneal scars and staphylomas may undergo retrogressive metamorphosis with the deposition of hyaline masses and lime particles in them. Purulent ulcers may form, which go on to perforation and may even cause panophthalmitis and subsequent atrophy of the eyeball. Ulcers thus formed were named by Arlt *atheromatous ulcers*. The condition is also called *scar keratitis*, and, according to Fuchs, is due to entrance of bacteria through the diseased and feebly resisting epithelium.

If after inflammation of the cornea, with loss of its super-

ficial layers, the intra-ocular pressure bulges forward the remaining lamina into an opaque elevation, the condition is called *kerectasia*. This differs from an ordinary partial staphyloma because there has been no perforation, and the iris tissue is not involved in the process.

If all the layers of the cornea down to the posterior elastic lamina are destroyed, and this protrudes through the opening in a small, translucent, hernia-like pouch, surrounded by a rim of opaque cornea, it is known as a *keratocele*.

An orifice remaining after a wound, or more commonly because of the failure of an ulcer to heal, is designated *fistula of the cornea*. It may last for a long period and stubbornly resist efforts at cure. It has been recommended to touch the mouth of the fistula with a point of lunar caustic, and even to pare the edges and introduce a corneal suture. A cicatrix of horny nature growing from the cornea has been reported by Arnold Lawson, and he thinks the epithelium covering cicatrices may not infrequently become cornified.

**Treatment of the Results of Corneal Ulceration.**—Satisfactory results follow *massage of the cornea*. The massage movements should be made in a circular and radial manner, over the cornea, through the closed lids, after the introduction of a small piece of the yellow oxid of mercury salve into the conjunctival cul-de-sac. Some irritation accompanies the method, but may be allayed by the occasional use of a collyrium of boric acid and cocain. In place of finger massage *vibration massage*, introduced by Maklakow, may be employed. An Edison electric pen, the point being armed with a small ivory ball, is employed. The vibration rate varies from 200 to several thousand a minute. Subconjunctival injections of physiologic salt solution may aid in the absorption of corneal opacities following keratitis. Thiosinamin in  $\frac{1}{2}$ -grain doses and gradually increased has been recommended in the treatment of opacities of the cornea. The author has no experience with this remedy.

Alleman has revived the use of *galvanism* for the removal of corneal scars and has reported favorable results. A suitably prepared electrode is connected with a battery, the



cathode being applied directly to the anesthetized surface of the cornea, and the anode to the soft tissues of the cheek. Usually a current of from 1 to  $1\frac{1}{4}$  milliampères gives the best results. The *séance* lasts at the beginning of the treatment for one minute, and is gradually increased to three or four minutes. Great care should be taken not to produce too much reaction.

Dense leukomas cannot be influenced by the practice of massage. A sufficient number of cases treated by galvanism have not been reported to determine its value. Vision may be improved by an iridectomy for new pupil, and the appearance of the eye by tattooing the cornea with India ink. Attempts have been made at transplantation of rabbit's cornea for the relief of dense central opacities, but, although von Hippel has reported some instances in which he was encouraged, the method does not seem likely to meet with sufficient success to warrant its adoption.

The treatment of staphyloma in the first place is preventive, and those measures already described in connection with impending perforation of the cornea, and perforation after its establishment, are indicated—namely, a compressing bandage and the use of eserine or, under some circumstances, atropine. If, in spite of this, the bulging continues, paracentesis of the anterior chamber or an iridectomy opposite the clearest part of the cornea may be performed. If the disease has been so extensive that a complete and unsightly staphyloma has formed, which is the seat of pain and a source of danger to the fellow eye, excision of the globe is indicated, or one of the various substitutes for the operation of enucleation (page 695).

**Xerotic Keratitis** (*Keratomalacia*; *Necrosis Corneæ*; *Infantile Ulceration of the Cornea, with Xerosis of the Conjunctiva*).—This disease is characterized by a dryness of the conjunctiva and a destructive ulceration of the cornea, and usually appears in infants during the first year of life.

**Cause.**—Formerly the disease was believed to be dependent upon encephalitis, a theory no longer tenable. It occurs only in anemic, badly nourished individuals. It has been seen accompanying meningitis, measles, and variola, and among chil-

dren with diarrhea, and those who are inmates of homes whose surroundings are bad. Bacilli have been found, but the special microbe, if it exists, has not been certainly isolated. The disease is not a common one. A somewhat similar condition has been described in the eyes of negro children in the South (Kollock).

**Symptoms.**—In the beginning there are conjunctival congestion and lachrimation, but the peculiarity of the disorder is the development of the appearances described under epithelial xerosis (page 267), in connection with the corneal lesions. A gray haze, rapidly turning into ulceration, appears in the cornea, followed by inflammation of the iris and the formation of hypopyon. Perforation of the cornea and destruction of the eyeball may result. Both eyes, as a rule, are affected, one earlier than the other.

The *prognosis* is very unfavorable; the patients usually die of the wasting disease which has occasioned the trouble, or of an intercurrent pneumonia. In some cases streptococci have been found in the local lesions, and foci of these micrococci scattered throughout the body.

**Treatment.**—This resolves itself, besides the ordinary treatment of severe corneal ulceration, into the administration of the internal remedies which are indicated by the general state of the patient.

**Neuroparalytic keratitis** is the name applied to an ulceration of the cornea which arises when this structure becomes anesthetic, because it is severed from the influence of the trigeminus.

**Cause.**—The corneal lesion has been ascribed to a trophic change; to the lessened power of resistance which the cornea in its insensitive condition presents to external injuries; to the irritation of the fifth nerve by the lesion; to micro-organisms; and to increased evaporation from the surface of the cornea.

Disease of the Gasserian ganglion, or its removal for trifacial neuralgia, disease of the nuclei of the fifth pair, periostitis of the orbit, syphilitic deposits, and fracture of the skull may cut off the trigeminal influence and cause the affection. A combination of the trophic and traumatic theory best ex-

plains the disorder ; foreign substances remain undetected upon the insensitive cornea, whose resisting power is weakened through loss of trophic influence.

**Symptoms.**—The keratitis begins in the true corneal tissue, and rapidly spreads forward until the central necrosis or slough separates, and perforation of the cornea with prolapse of the iris occurs. The anterior chamber may contain pus, or pus mixed with blood. Beyond and around the central abscess the corneal tissue is comparatively clear, but in the periphery there are secondary foci of infiltration, closely connected with inflammation of the neighboring conjunctiva. The surface of the cornea and conjunctiva is anesthetic. The intra-ocular tension is diminished. There may be considerable pain and irritation, or these symptoms may be absent.

The *prognosis* is unfavorable, and in spite of treatment destructive inflammation often results.

**Treatment.**—The usual treatment of corneal ulcers is necessary, and the affected eye should be excluded from the influence of external irritants, either by a carefully applied antiseptic bandage or by a Buller's shield ; it has been recommended to stitch together the lids. Experimental evidence indicates the propriety of preventing evaporation by keeping the eye in a moist atmosphere.

**Herpes Corneæ.**<sup>1</sup>—The corneal lesions associated with herpes zoster ophthalmicus have been described on page 197. The present disease consists of a vesicular eruption upon the cornea, which breaks down and forms an ulcer, characterized by a denudation of epithelium not unlike that produced by injury.

**Causes.**—Horner has described herpes of the cornea with whooping-cough, intermittent and typhoid fever, and, in general terms, with those affections in which herpes of the lips and nose is found. It is seen in acute and subacute disease of the posterior nares and pharynx, and also in affections of the respiratory apparatus generally (pneumonia ; bronchitis).

**Symptoms.**—The disease begins with a series of transparent

<sup>1</sup> This term, as Horner observes, is often incorrectly used as synonymous with phlyctenular keratitis.

vesicles upon the cornea, which have been compared to a string of small beads. The vesicles are placed in a circle, or run in a diagonal or irregular line across the cornea. They speedily rupture and leave an open patch, deprived of epithelium, which is anesthetic and has irregularly serrated margins, upon which the remains of vesicles may be seen. It is well shown by fluorescein staining.

The progress of repair is slow, and is often interrupted by the reappearance of fresh vesicles. The disease may be complicated with pus in the anterior chamber and iritis. Pain in the eye and brow, photophobia, lacrimation, and a gritty sensation are the subjective symptoms.

**Treatment.**—This consists in relieving the general condition; usually quinin in full doses is indicated. During the stage of irritation, atropin and cocain, or, better, holocain,

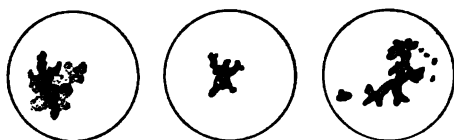


FIG. 105.—Showing various shapes and positions of herpes ulcers (Haab).

warm compresses, and dark glasses are needed. Calomel dusted into the eye is recommended. After the formation of the ulcer the treatment is conducted on general principles. A pressure bandage is of advantage, and in many cases an application of tincture of iodine is useful; the actual cautery may be needed to subdue stubborn ulcers of this character.

**Keratitis bullosa** in many instances is a symptom and not a separate disease, inasmuch as it consists of the formation of one or more small blebs of short duration (*keratitis vesiculosa*), or of larger blebs of more enduring existence (*keratitis bullosa*), upon the cornea of an eye the subject of iridocyclitis, interstitial keratitis, or glaucoma.

**Cause.**—This affection formerly was attributed to a mechanical effect due to increased intra-ocular tension. Its etiology is not entirely clear, but probably depends, according to Fuchs, upon an abnormality of the lymph circulation, in

which a stasis takes place resulting in edema of the cornea and a blister-like elevation of the corneal layers and the epithelium. Sometimes moderately large vesicles form upon a cornea otherwise normal, and in one reported case malaria was believed to be the chief factor in their causation.

**Symptoms.**—In addition to the formation of the blebs, there are burning pain, photophobia, injection of the bulbar conjunctiva, and rupture of the vesicles, leaving an abrasion which may go on to ulceration. There is a strong tendency to recurrence, and with each new formation of vesicles the violent inflammatory symptoms are repeated.

**Treatment.**—This consists in puncture of the blebs and suitable local measures, according to the causative disease. In severe cases iridectomy and even enucleation may be needed. The recurrent character and the remissions which have been described have suggested the use of antiperiodic doses of quinin; and these have been given with good results.

**Relapsing Traumatic Keratitis Bullosa** (*Relapsing Erosion of the Cornea; Traumatic Keratalgia*).—In general terms the symptoms of this affection are these: Some time—several weeks or several months—after an abrasion of the cornea by a finger-nail, a twig, or similar object, the patient experiences, almost always on awakening in the morning, some difficulty in opening the eye, followed, when the lid is raised, by marked foreign body sensation, decided epiphora, flushing of the eyeball, and sharp neuralgic pain. Each movement of the lid is painful, and the “attack” continues from one-half to several hours, when, usually by afternoon, the symptoms subside and the eye is again apparently normal. Careful examination during the continuance of the irritative signs just described will reveal on the cornea a small ruptured vesicle, or a larger blister or bulla, or sometimes simply an erosion of the superficial epithelium, without indications of vesicle or bulla. Occasionally the only lesion to be detected is the scar or macula caused by the original injury, without loss of epithelium. These attacks may recur at short or long intervals, for weeks, months, and even years.

**Treatment.**—The ordinary treatment of corneal ulcer is in-

licated, and of especial advantage are a pressure bandage and massage with the yellow oxid of mercury.<sup>1</sup>

The second group of corneal inflammations is the *non-ulcerative*, and includes a variety of affections usually unattended by the development of ulcers, but among which some are described that occasionally present the lesions seen with ulcers in the course of their development. Abscess of the cornea, if it remains with unbroken boundaries, is a suppurative but non-ulcerative affection, and naturally belongs in this group. As in many instances its walls break down and an open ulcer results, it has been described with the ulcerated forms of corneal disease.

**Vascular keratitis** is a superficial vascularity and opacity of the cornea, and is seen in pannus caused by granular lids (page 258) and in phlyctenular pannus, the result of many relapses of phlyctenular keratitis (page 281).

Another form of vascular keratitis is characterized by the formation of two opposite vascular areas at the upper and lower margins of the cornea, which approach each other until the vascularization is complete. The disease is met with in young adults and in unhealthy, scrofulous, and underfed children. The second eye usually is attacked, and, as has been pointed out by Carter, the character of the disorder indicates a perverted action of the nerves which govern the areas affected, and places it in analogy with herpes.

**Symptoms.**—These begin insidiously with slight intolerance of light, preceding the appearance at the upper margin of the cornea of a crescent of closely arranged blood-vessels, which, as they advance, push before them a border of corneal opacity. Simultaneously the same appearances become manifest at the lower margin. Clearing begins at the borders, and the whitish opacity which remains leaves the center last of all. In the early stages the disease may be mistaken for conjunctivitis. All cases must be regarded with anxiety, and some do not clear up entirely (compare page 309).

<sup>1</sup> Herpes of the cornea, the corneal complications of herpes zoster ophthalmicus (page 197), and the three varieties of the keratitis just described have been gathered by Fuchs under the general caption *keratitis with vesicle formation*.

**Treatment.**—Local irritants are contraindicated. Atropin, cocain, and warm fomentations in the early stages, and later a salve of the yellow oxid of mercury, or calomel, are useful. The best internal treatment is a prolonged course of iron and bichlorid of mercury. Iridectomy for new pupil may be necessary, and the convex side of the vascular crescent may be touched with the galvanocautery.

**Interstitial Keratitis** (*Syphilitic, Inherited, Specific, Parenchymatous, Strumous, and Diffuse Interstitial Keratitis*).—This is a diffuse keratitis in which a chronic inflammation of the whole thickness of the cornea takes place, until, usually without ulceration, but always with superficial or deep vascularization, the cornea passes into a condition of universal thick haziness.

**Causes.**—The majority of cases of interstitial keratitis are due to inherited syphilis; in rare instances it is caused by acquired syphilis. In spite, however, of the not infrequent occurrence of this affection, the exact cause of its development is not always readily determined. Evidence of inherited syphilis is present in between 60 and 70 per cent. of the cases, and it is probable that this percentage would rise higher if the separation of typical cases was made from such as are only similar in appearance to the true disease.

The disease may also be caused by tuberculosis, rachitis, scrofula, malaria, rheumatism, the climacteric, and depressed nutrition. It is occasionally seen in animals.

It is most frequently seen between the ages of five and fifteen, occasionally as early as three years, but rarely after thirty. A few cases are on record as late as the sixtieth year of life. Some statistics show that interstitial keratitis is more frequent in females than in males. The average age for males to be attacked is about seventeen, while women are affected a year and a half earlier, because a large number of cases occur about the supervention of menstruation. The greater immunity of the male sex from this disease does not, however, appear in all cases, other statistics showing an equal susceptibility, and still others a greater liability on the part of males.

Interstitial keratitis appears to have been aggravated by the

development of menstruation, and also to have undergone improvement by establishment of the menstrual molimen. It is probable that the affection occasionally arises *in utero*, and a congenital form of interstitial keratitis, not differing in appearance from the ordinary or postnatal form of the disease, has been described (Randolph).

**Symptoms.**—After a few days of slight ciliary congestion and watering a faint cloudiness appears, usually, but not always, near the center of the cornea. The spots of haze, if carefully examined, will be found to be interstitial opacities, composed of round cells—that is, within the structure of the cornea itself, and not on either surface.

In two or three weeks they spread until the whole cornea is invested with a diffuse haziness, veiling or completely hiding the iris, except, perhaps, through a narrow rim at the margin of the cornea. The steamy surface has often been compared to ground glass. Careful inspection will reveal that the opacity is not uniform, but contains saturated whiter spots scattered through it, which have been described as “centers of the disease.” There are always at this stage ciliary congestion and some pain and dread of light. Blood-vessels derived from the ciliary vessels are thickly set in the layers of the cornea and produce a dull red color—“the salmon patch of Hutchinson.” These patches may be small and crescent-shaped, or large and sector-like. In one type (referred to on page 307) the vascularity creeps from above and below until the entire cornea is cherry red.

The subjective symptoms of irritability and photophobia are more pronounced in strumous children who are at the same time syphilitic. Ulceration rarely occurs, but none the less ulcers of discoverable size are sometimes present, and hypopyon and an appearance resembling an accumulation of pus in the layers of the cornea have been reported. Iritis and the formation of posterior synechiæ are not uncommon, in one form the iritis being associated with deposits on the posterior layer of the cornea and the formation of anterior synechiæ. Inflammation of the ciliary region is occasionally encountered; secondary glaucoma and shrinking of the eyeball may follow.



In the course of time, varying in accordance with the treatment, the eye begins to clear, usually from the periphery. Perfect recovery of the transparency must be rare, although the remaining haze may be slight. Years after an attack of interstitial keratitis minute vessels, nearly straight, branching at acute angles and short bends, may be detected in the cornea. These appearances have been especially described by Nettleship and Hirschberg, the latter observer stating that the vessel formation never subsides entirely, and he has seen this condition, with the aid of a corneal loup, thirteen years after an attack.

In addition to the complication of iritis and inflammation of the ciliary body, more or less retinitis is very apt to be pres-

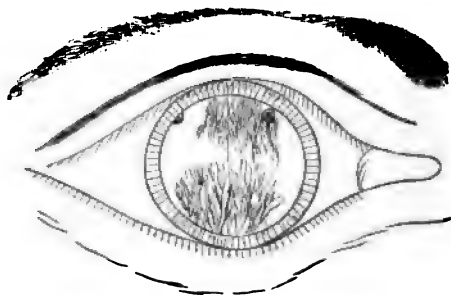


FIG. 106.—Vessel formation in the cornea after interstitial keratitis (Hirschberg).

ent, sometimes not detected until after the clearing up of the cornea. Disseminated choroiditis, and even optic neuritis and retinal hemorrhage, have also been reported. The presence of the vessels and the deposits in the retina and choroid after the disease has subsided may be utilized for the diagnosis of inherited syphilis.

The subjects of typical forms of this disease often present a remarkable combination of physical defects. The dwarfed stature, the coarse, flabby skin, the sunken nasal bridge, the scars at the angle of the mouth and also of the nose, the malformed permanent teeth, in which the central incisors have vertically notched edges (Hutchinson's teeth), indelibly stamp the inheritance of the patient. This character of teeth is present in

between 20 and 30 per cent. of the cases. Indeed, it has been seen as frequently as 31 times in 48 cases. The presence of deafness, cicatrices in the pharynx, chronic periostitis of the



FIG. 107.—From a photograph of a patient in the Children's Hospital, the subject of inherited syphilis and interstitial keratitis.

tibia, synovitis of the knee-joint (symmetric or unilateral), and indurated lymphatic glands further emphasizes the syphilitic taint.

**Diagnosis.**—The course is usually quite typical, and the associated symptoms characteristic. The tension of the eyeball and the age of the patient in most instances help to exclude primary glaucoma, while the history and character of the inflammation differentiate it from old corneal maculas and from the diffuse infiltration of the cornea which is sometimes seen as the result of injury.

The presence of the minute straight vessels is good evidence of former interstitial keratitis. These vessels must be distinguished from those which remain after pannus from granular lids. According to Hirschberg, in the latter condition they are more superficial and pass into anterior conjunctival vessels. There are well-formed anastomoses, the broader veins are accompanied by finer arteries, and there are peculiar ramifications of the small deep vessels. The vessels seen in corneal scars after ulceration are confined to these cicatrices. The rest of the cornea is free.

Certain atypical cases of interstitial keratitis have been described, namely, forms in which the opacities are *stripe-like*; others in which they are *ring-like*; others presenting the appearance of pus in the layers of the cornea, the so-called *abscess forms*; others in which there is a combination of *interstitial keratitis* and *keratitis punctata*, and that form which is spoken of as *central annular interstitial keratitis*, especially described by Vossius, and usually seen in individuals under the age of twenty, and for which a definite cause has not been found. The variety which begins as a *marginal vascular keratitis* has been described.

**Prognosis.**—From six to eighteen months are usually consumed in the development of the various stages of the disease. The second eye is almost certain to be attacked in from a few weeks to two months. In rare instances the interval is many months, even a year; it may be delayed from five to six years. The patient or his friends must be warned of this fact.

A return to perfect transparency is unusual. The vessel formation in the cornea probably never subsides entirely, but even long-continued opacity in the course of time may markedly lessen, and reasonable vision be restored. The occasional on-

set of deep-seated inflammation of the ciliary region, and the fact that after the cornea has cleared evidences of former choroiditis, retinitis, or disease of the optic disc, with glaucomatous cupping, may be discovered, must not be forgotten in rendering a prognosis.

Relapses are frequent, not only of the corneal disease, but of the complications found in the iris and retina. It has been taught by some observers that the disorder is more severe now than in former times.

**Treatment.**—All irritating applications are harmful. Atropin to maintain mydriasis, prevent iritis, and allay inflammation should be systematically employed. If the irritation is great, this drug may be cautiously combined with cocain. Any high grade of inflammation calls for the frequent use of hot fomentations, and tenderness in the ciliary region will be relieved by a leech applied to the temple. The eyes may be protected from dust and light by goggles or a dark shade.

The best general medication is a long-continued course of mercury. Certainly in children, and probably in all instances, the most satisfactory method of administration in the earlier stages is by inunctions, 1 dram of the ointment rubbed into the skin once or twice a day according to circumstances. It is a good plan to order the mercurial ointment to be put up in 1 dram masses, thus securing the inunction of a definite quantity. The usual precautions in regard to changing the spots for the rubbings are to be observed. Whenever slight tenderness of the gums is apparent, the remedy should be discontinued, a chlorate of potash mouth-wash should be ordered, and the patient put upon a course of iodid of potassium. Subconjunctival injections of bichlorid of mercury have been advocated, but in the author's experience have proved an unsatisfactory method of administering mercury in this disease. Similar injections of saline solutions are often of decided advantage. Some surgeons recommend that mercury be given in the form of hypodermic injections. An experience with this plan of treatment has not caused the author to abandon the older methods of administration.

During the time the inunctions are being employed, cod-

liver oil may be exhibited; later, bichlorid of mercury is a valuable remedy, and, as many of the patients are anemic, this is advantageously combined with the tincture of the chlorid of iron. Suspicion of malaria calls for quinin and arsenic, and in any event they are useful adjuvants. If rheumatism or rachitis is present, the salicylates and phosphates are worthy of trial. A course of tonic treatment, nourishing diet, exercise, and healthful surroundings are necessary; in short, all measures are indicated which elevate the standard of the patient's general health.

When all irritation has subsided, clearing of the remaining opacity is facilitated by the use of a salve of the yellow oxid of mercury, together with massage of the cornea, or by the local use of a solution of iodid of potassium. Subconjunctival saline injections may facilitate the absorption of the corneal opacities. Iridectomy, if the tension rises and glaucoma threatens, may be necessary; it is evident that it should be employed for new pupil when stubborn central opacity remains.

**Keratitis Punctata.**—This affection is always secondary to disease of the iris, ciliary body, choroid, or vitreous, and hence is a symptom rather than a specific disease. It is characterized by a precipitate of opaque dots, generally arranged in a triangular manner, upon the posterior elastic lamina of the cornea (Descemet's membrane—hence also called *descemetitis*). The overlying cornea is hazy, its surface at times slightly uneven.

The same name is also applied by some writers to those cases in which isolated whitish spots, surrounded by a cloudy area, appear in the parenchyma of the cornea. The disease is seen in young subjects, and is probably syphilitic in origin. Inflammatory evidences, the appearance of the white dots in the cornea, and later the development of iritis, with more diffuse corneal infiltration, characterize the disease. Small dotted deposits of lens matter on the back of the cornea after discission may simulate this affection (Fuchs). The eye, however, is uninfamed.

Iodid of potassium and bichlorid of mercury are proper

internal remedies. Atropin mydriasis should be maintained, provided the tension does not rise; later iridectomy may be required to check the iritis, or for optical purposes.

**Keratitis Profunda** (*Central Parenchymatous Infiltration; Circumscribed Parenchymatous Keratitis*).—This form of keratitis is characterized by the formation of a grayish opacity in the deeper layers of the cornea, sometimes without severe irritative symptoms and unassociated with ulceration.

The *cause* is often not discoverable; sometimes cold, rheumatism, and malaria may originate the disorder; it undoubtedly may develop from an injury.

The following is Fuchs's description of this disease: The gray opacity, usually in the center, is covered by the superficial corneal layers, which are hazy and stippled, but not absorbed. Close examination (with a loupe) of the corneal opacity resolves this into individual points, spots, or gray interlacing stripes. The deposit slowly absorbs without ulceration, and commonly with only slight vesicle formation, and leaves the cornea clear, or permanent opacity may remain. Symptoms of inflammation may or may not be present; there is hyperemia of the iris. The duration of the disease is from one to two months.

The *treatment* requires atropin, dark glasses, and, later, yellow oxid or similar salve to aid resolution. The constitutional treatment is governed by the probable cause.

Among the more uncommon forms of corneal inflammation the following may be mentioned:

**Keratitis Superficialis Punctata** (*Keratitis Subepithelialis Centralis; Keratitis Maculosa; Noduli Corneæ; Relapsing Herpes Corneæ*).—This disease, which probably is akin to the herpes-like corneal inflammations, appears under several forms, just as it has been described under several names, either different types of the same disorder, or closely analogous manifestations.

Generally it begins with the symptoms of a sharp conjunctivitis in which the secretion is watery, while at the same time there is catarrhal disease of the respiratory tract. In two or three days numerous small punctiform or linear spots appear,

not immediately beneath the epithelium, but below Bowman's membrane. The overlying cornea is slightly hazy, and the epithelium above the spots a little elevated, the foci being more numerous near the center of the cornea than at the periphery. The cornea intervening between the spots is somewhat hazy, and contains small points and gray lines radiating hither and thither, comparable to the fine fissures in ice. The disease is tedious and may last for months. It occurs in young individuals, usually is bilateral, and is unaccompanied by loss of epithelium, ulcers, iritis, or hypopyon.

Stellwag finds the foci of large size, most commonly in the periphery, that the disease always begins with pain in the brow, and that the iris may be involved (*nummular keratitis*). It is analogous to interstitial forms of keratitis. In his cases the duration was much shorter, cure having been effected in two weeks.

The anatomic nature of the spots is uncertain; probably they are enlarged and opaque corneal corpuscles, or lymph-spaces filled with opaque matter. The cause of the disorder is unknown (trophoneurosis is suggested), except that it is connected with catarrhal affections of the upper air-passages. It is analogous to herpes, but differs from it in the absence of vesicle formation and herpes of the face, its bilateral character, and the great number of corneal spots or foci.

The *treatment* should be directed to the mucous membrane of the nasopharynx. Locally, during the state of irritation, atropin is indicated, and later yellow oxid salve. Full doses of quinin would seem to be called for, and it has been recommended to use the constant current along the region of the distribution of the supra-orbital nerve.

**Keratitis Marginalis.**—Under this name, which is here used in a sense quite different from that employed on page 281, Fuchs has described a rare form of keratitis in which a yellowish-gray zone of opacity, immediately joining the sclera, pushes into the clear cornea, accompanied by severe inflammatory symptoms, and occupies about one-half of the corneal circumference. The vessels of the limbus cover the opacity; in several weeks these and the inflammatory symptoms sub-

side, leaving a rim of infiltration somewhat like an *arcus senilis*, save only that it joins the sclera directly and is not separated from it by a stripe of clear cornea. The disorder is unaccompanied by ulceration.

It resembles the angular corneal opacity, which appears in connection with scleritis, and which is known as *sclerotizing keratitis* (see page 330), but differs from it in the absence of any preceding scleritis. The disorder occurs in elderly subjects.

**Keratitis Annularis.**—According to Fuchs, this is an individual type of ring-like or disc-like keratitis, to which he gives the name *keratitis annularis et disciformis*, and which has also been described by Grunert. It should be distinguished from the annular keratitis of Vossius (page 312). The disease is found in persons in middle life, and appears frequently after slight epithelial defects, whether these are caused by injury or by herpes of the cornea. It is characterized by a delicate gray disc which occupies nearly the middle of the cornea, and which is separated from its transparent margin by an intensely gray, sharply marked border. The superficial layers of the cornea are smooth and unirritated. In the course of the disease, which lasts usually for several months, small ulcers may appear, and under most circumstances there is a decided opacity after the subsidence of the disease. Fuchs thinks that this disease has a position between serpiginous ulceration and the flat, disc-shape ulceration after herpes of the cornea. All three depend upon an infection of the cornea which gains entrance through a breach in the epithelium. The difference depends upon whether there is a deep or a superficial involvement of the tissue, which in its turn depends probably upon the character of the bacteria.

**Grill-like Keratitis.**—This disease, described by Haab under the name "gittrige keratitis," consists of a central corneal opacity, which by transmitted light is seen to be composed of forked lines with points scattered through them resembling grill work. The process is a degenerative one, and is probably due to a deposition of hyalin in the deeper layers of the corneal epithelium and in Bowman's membrane.



**Filamentous keratitis** is an unusual condition characterized by the development of small threads of tissue from wounds (*traumatic filamentous keratitis*) or herpetic spots (*spontaneous filamentous keratitis*) on the cornea. The tags have a bulbous extremity, are often twisted like a rope, and are attached to the cornea by a pedicle. Their appearances must be studied with a loupe or microscope. They represent an active proliferation of epithelium. They may speedily disappear, or persist, or recur after removal.

**Riband-like keratitis** (*primary opacity of the cornea; transverse calcareous film of the cornea; keratitis trophica; keratitis petrificans* (Suker)) appears, as pointed out by Nettleship, in two forms.

In the one, usually in elderly people, the exposed part of the cornea is invaded in a transverse direction by a *smooth subepithelial* opacity, oval in shape, which can be chipped off, and is composed of an incrustation of lime-salts. Hyaline deposits also appear in the cornea. There is no ulceration and no change in the overlying epithelium. The opacity is sharply limited, and the remainder of the cornea is clear. The disorder almost invariably is symmetric, and is situated upon the exposed cornea, although deposits like the transverse band may also be found in other parts of the cornea. A margin of the cornea at each end is free. Gout and excess of uric acid in the blood have been suggested as constitutional causes, a suggestion strengthened by the occasional occurrence of insidious iritis, glaucoma, and hemorrhagic retinitis. It may be mistaken for the opacity which occurs from the injudicious use of salts of lead.

In the other type of the affection a horizontal band of opacity, grayish-brown in color, crosses the corneæ of eyes which have long been blind from iridocyclitis, sympathetic ophthalmia, and glaucoma. Here the stripe is less uniform, less sharply defined, and consists of a *roughened*, transverse opacity. The calcareous nature of the other type may be wanting. As it occurs in the lower third of the cornea, or that part exposed when the eye is rolled up, and in an eye with impaired nutrition, the affection has been considered trophic

in its nature. According to Best, the deposits are composed of lime and connective tissue.

**Blood-staining of the Cornea.**—This phenomenon has been observed in cases of hyphemia and increased intra-ocular tension. The cornea assumes a smoky or rust-colored tint, except at its periphery, the clear portion being sharply separated from the cloudy area, which, however, is usually more pronounced in its center. The appearances closely resemble those of an amber-colored lens dislocated into the anterior chamber. With the microscope numerous granules (probably hematoidin) are found deposited in the substantia propria, which, according to Griffith, have entered the corneal tissues by endosmosis in a state of solution. The lesions have been studied by T. Collins, Vossius, Weeks, and J. Griffith; according to the observations of Collins and the author, it requires at least two years for the stains to disappear.

**Arcus senilis** (*gerontoxon*), or a circle of fatty degeneration just within the margin of the cornea, is, as its name implies, almost invariably found in old persons. A true arcus is always separated from the adjacent sclera by a thin stripe of clear cornea. Occasionally a genuine example of this affection appears to have been noted in children (Hansell). Instances which have been reported at birth must not be confounded with an arciform opacity, the result of ulceration.

The affection requires no treatment, and its presence appears not to interfere with the healing of wounds; for example, in cataract incision.

A senile degeneration in the form of *sclerosis* and *atrophy of the corneal margin*, according to Fuchs, may arise in connection with arcus senilis. A furrow forms just within the corneal margin without ulceration.

**Conical Cornea** (*Keratoconus*).—This consists of a cone-shaped bulging forward of the cornea, and is rarely congenital. It is mostly seen in women, and usually does not develop until after the age of fifteen. Exhausting illness, menstrual disturbance, and especially chronic dyspepsia, have been observed to be associated with the development of conical cornea,

the immediate cause being a disturbance in the relation of the intra-ocular pressure to the resistance of the cornea.

The cone is transparent in most instances; occasionally its apex is slightly opaque. The bulging slowly progresses, but does not rupture nor ulcerate. After years it comes to a standstill. One or both eyes may be involved, commonly the latter, the second eye being affected some time after its fellow. The eye becomes myopic and highly astigmatic. Slight forms of conical cornea may be overlooked, unless the shadow-test is employed and the characteristic reflections observed.

**Treatment.**—Although no form of glass or no optical apparatus may avail in advanced cases, a careful trial should always be made with spherocylindric combinations, and in some instances their employment in unusual combinations will markedly improve visual acuity. It is always wise to use eserin

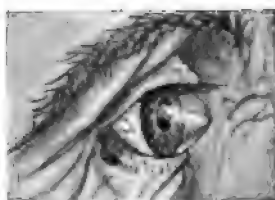


FIG. 108.—Conical cornea.

(gr.  $\frac{1}{8}$ —f3j) for several weeks before attempting the correction (Wallace).

If the apex of the cone appears to be thinning, a weak solution of sulphate of eserin and a compressing bandage are indicated.

In advanced cases an operation is advisable, having for its object the substitution of a contracting cicatrix for the tissue at the apex of the cone, which shall diminish the excessive curvature. Several plans are suggested: (1) Cutting off a small, superficial flap and subsequently cauterizing the surface, associated with repeated paracentesis of the cornea, and later a small iridectomy for optical purposes; (2) cutting off the flap and drawing the edges of the wound together with delicate sutures; (3) cutting from the apex of the cone a small disc with a trephine; (4) multiple punctures with fine needles; (5)

obtaining the desired loss of substance by the application of a galvanocautery. As the resulting scar is directly central, an iridectomy for optical purposes will usually be required, an operation indicated under any circumstances if the tension rises.

**Hydrophthalmos** (*Hydrophthalmos congenitus; Keratoglobus; Megalocornea; Buphthalmos; Glaucoma congenitum*).—In this affection there is slow but progressive enlargement of the eye in all its diameters; the cornea is flattened, the pupil dilated and sluggish, the iris atrophic and sometimes tremulous, the sclera thinned and of a bluish color, and the anterior chamber deepened; the tension is raised. In the course of time the cornea may become cloudy (*keratoglobus turbidus*), although this is not always the case (*keratoglobus pellucidus*). The papilla may be deeply cupped.

The affection appears at birth or shortly afterward, and its incipient stages are believed to be intra-uterine. The precise cause is not accurately determined. It has been ascribed to an intra-uterine iridokeratitis with increased intra-ocular tension; in other words, a form of congenital glaucoma. Pyle divides the disease into two classes: true hydrophthalmos, depending upon congenital defective development of the cornea, iris, or filtration channels, and hydrophthalmos secondary to fetal intra-ocular inflammation.

The *prognosis* is unfavorable; the affection usually progresses to blindness. Iridectomy has been practised with poor success; some favorable results with repeated sclerotomies have been reported. Eserin or pilocarpin should be tried. Sympathectomy has been suggested.

**Injuries of the Cornea.—Traumatic Keratitis.**—These comprise—(1) Foreign bodies; (2) erosions; (3) wounds; and (4) burns and scalds.

*Foreign bodies*, as particles of sand, fine splinters of iron, and bits of emery, may either lodge upon the epithelium or become imbedded in the substance of the cornea. If they are sharp like a splinter of iron or small thorn from a chestnut-burr, they may partially penetrate the membrane.

The pain of even a minute foreign body is considerable; the eye waters and grows red, and the source of irritation is com-

monly referred to the under surface of the upper lid, although the intruder may be directly upon the center of the cornea.

To remove an imbedded foreign body a drop of a 4 per cent. solution of cocain is instilled, the upper and lower lids are held apart with the thumb and forefinger of the surgeon's hand, while with the right hand he takes a fine needle, or a spud, and lifts the body from its position with as little injury as possible to the cornea. Sometimes, if the situation is deep, several digging motions with the instrument will be required to dislodge the substance. The area should afterward be inspected by means of a 2-inch lens and oblique illumination. In any case in which the operator is not sure that he has removed the foreign substance he may resort to the fluorescin method described on page 60. If the substance has been iron or emery, a small, rust-like spot will often remain. *Powder grains* may be removed by touching them with a fine galvano-cautery point (E. Jackson).

If the spicule has partially penetrated, it may be necessary to pass a broad needle through the cornea behind it to secure a surface against which to work, and to prevent the manipulations from pushing it entirely through the cornea and into the anterior chamber.

After the removal of the foreign body, the resulting irritation may be allayed by a drop of atropin; the use of a bandage for a few days will facilitate the healing of the ulcer. Disinfection of the conjunctival cul-de-sac with a bichlorid lotion and sterilization of the spud should be secured. Among oyster shuckers a form of keratitis is prevalent (*oyster-shucker's keratitis*), caused by small particles of oyster shells striking the cornea and producing ulcers. Randolph has shown that the disease depends upon the irritating chemical ingredients in the shell and not upon micro-organisms. It is best treated by atropin and mild antiseptic lotions.

*Erosions.*—A superficial loss of epithelium caused by the contact of a sharp body, like a finger-nail, in itself may be insignificant, but may lead, through septic infection, to a severe ulceration, particularly if the injured eye is exposed to the discharge from an inflamed lacrimonasal duct.

The *treatment* consists of the instillation of an antiseptic lotion, for example, bichlorid of mercury (1 : 8000), and the use of atropin, with a compressing bandage to immobilize the lids until healing takes place, provided no septic discharge is present. Relapsing erosions of the cornea and traumatic keratalgia have been described on page 306.

*Wounds of the cornea* naturally divide themselves into *non-penetrating* and *penetrating*, and differ in character according to the implement which has inflicted them.

*Non-penetrating* wounds partake of the nature of erosions, and, like them, may be in themselves of minor importance, but may result in sloughing ulcers through microbic infection.

The treatment already described is applicable.

A *penetrating* wound allows the escape of the aqueous and renders incarceration of the iris liable, with all the possibilities described in connection with perforating ulcers. The wound may injure the lens and cause traumatic cataract, or involve the ciliary region and cause sympathetic inflammation, or become infected and originate a sloughing keratitis or a panophthalmitis.

After a perforating wound of the cornea the eye should be thoroughly disinfected, the iris, if prolapsed, replaced if possible, and eserine or atropin instilled according to the situation of the injury. If replacement is not possible, the prolapsed portion should be seized with iris forceps and excised, after the manner of performing an iridectomy. In either event the subsequent treatment requires rest, disinfection of the conjunctival cul-de-sac, and a carefully applied antiseptic compressing bandage.

The tendency to traumatic iritis may be combated by the frequent use of cold compresses. Inflammatory reaction would call for a leech to the temple. In severe corneal wounds, involving the iris, lens, and ciliary body, the question of enucleation or evisceration must be decided. Gaping wounds of the cornea may be closed with fine silk sutures. To protect the cornea when extensively wounded de Wecker covers it with conjunctiva, which is dissected loose in such a manner that it may be united over the cornea by a purse-string

suture. When the cornea is healed, the conjunctiva covering is dissected loose.

*Burns and scalds* are produced by the contact of acids, lime, molten metal, and hot water or steam, and the general management of such cases does not differ from that of similar accidents to the conjunctiva, which necessarily is involved (page 277).

Sometimes the burn may be superficial and the whole surface epithelium be changed into a white scum, which presents a most alarming appearance. The destroyed tissue, however, is speedily replaced by a new layer of epithelium. Burns with slaking lime and molten metal are those most liable to result in disastrous consequences, and may be followed by sloughing keratitis and even panophthalmitis.

All the various forms of corneal injury cause more or less severe inflammation, properly classed under the general term *traumatic keratitis*, and possess in greater or less degree the cardinal symptoms of keratitis—pain, lacrimation, photophobia, and disturbance of vision.

**Tumors of the Cornea.**—These are very rare, and include the growths which develop from the epithelium—*epithelioma*—or invade it by extension from the neighboring tissues—*sarcoma*. A few instances of *fibroma*, *papilloma*, and *primary sarcoma* have been reported. *Cysts of the cornea* have been described. Bietti has recorded one which developed from the tissue of a pseudopterygium.

*Dermoid* tumor is a congenital growth, and sometimes is associated with other anomalies of the lid and eyes. It occurs as a firm, hemispheric, yellowish-white growth, lying partly upon the cornea and partly upon the conjunctiva. The apex, often paler than the rest of the growth, is covered with short hairs. These, however, occasionally grow to an unusual length and have been seen protruding through the fissure of the lids and hanging down upon the cheeks. If undisturbed, the tumor may slowly enlarge, and has been reported to have attained the size of a walnut. Bilateral dermoids have been recorded.

These dermoids have been ascribed by Van Duyse to the

remains of amniotic adhesions and by Remak to invagination of the ectoderm. Microscopically, the growth represents the structure of the skin and its appendages. The presence of striped muscle-fiber and acinous glands, analogous to those in the conjunctiva, has been described in dermoid of the caruncle.

**Congenital Anomalies of the Cornea.**—*Microphthalmos* is that condition in which the entire eye remains in a more or less rudimentary state, and in which the cornea is too small in all its diameters. Pure cases of microphthalmos, according to Manz, are very rare; usually one or other of the component portions of the globe is wanting. Numerous theories have been expressed in regard to the etiology—incomplete closure of the fetal ocular cleft (Arlt), fetal illness *in orbita* (Wedl and Boch), intra-uterine sclerochorioretinitis (Deutsch-



FIG. 109.—Dermoid of the cornea (from a patient in the Philadelphia Hospital).

mann). The affection has also been ascribed to the influence of heredity.

*Megalophthalmos* has been described on page 321.

*Sclerophthalmia* or *sclerosis* is that condition in which the opacity of the sclerotic encroaches upon the cornea in such a manner that only the central portion remains transparent. It is due to an imperfect differentiation of the cornea and sclera at an early period of fetal life. It may be symmetric, and affect only the upper half of the cornea.

*Congenital opacities of the cornea* are seen in the form of milky spots which may clear up in later life, or as leukomas. Usually the iris is dimly visible through the clouded tissue. These opacities are due either to intra-uterine inflammation or to an arrest of development.



*Congenital staphyloma of the cornea* appears in the form of a true staphyloma, and is a rare affection. The abnormality depends not so much upon a malformation or an arrest of development as upon a fetal inflammation, which, according to Pincus, takes place in the second half of fetal life. Heredity probably plays some rôle in this and similar affections of the cornea. Congenital staphyloma of the cornea associated with dermoid formation has been reported.

*Congenital melanosis of the cornea* may appear in the form of a vertically oval area of brownish color in the center of this membrane. It has been ascribed to an abnormal development of the uveal tract (Kukenberg).

## CHAPTER VIII.

### DISEASES OF THE SCLERA.

THE sclera, constituting four-fifths of the covering of the globe of the eye, and being in intimate relationship by its under surface with the choroid and ciliary body, is subject to inflammations peculiar to itself, and to changes indicative of disease of these subjacent structures. Its close connection with the cornea associates the latter membrane in some phases of its diseases, and its union with the iris through the pectinate ligament establishes an anatomic connection, just as there often is a pathologic relation. The overlying bulbar conjunctiva necessarily participates in scleral inflammation.

The inflammations affect—(1) The episcleral tissue (*episcleritis*); and (2) the sclera itself (*scleritis*), and hence are *superficial* or *deep*. They further are *acute* or *chronic*, *diffuse* or *circumscribed*.

**Episcleritis** occurs in the form of small, dusky red, subconjunctival swellings, which usually appear in the ciliary region on the temporal side of the cornea, though patches may occur in any portion of the zone.

The conjunctival vessels over the patch are coarsely injected, and movable with the somewhat edematous conjunctiva. The episcleral vessels show a dusky congestion which is immovable. The elevation is back-shaped; sometimes tender to pressure and sometimes not, and there may or may not be much irritation and pain. In some cases of thickened phlyctenular disease of the corneal margin it is difficult to decide between this affection and episcleritis; what appears to be a patch of the latter may develop into the former.

The disease runs a subacute course, reaching its height in about three weeks, then gradually disappears, and leaves a somewhat dull area of discoloration marking its former posi-

tion. Relapses are frequent, both at the original seat or in new spots on the sclera, and these recurrences may happen again and again for months and even years.

**Cause.**—It is said to be more common in men than in women (Nettleship). Patches of episcleritis of the character described occur in the eyes of those who are much exposed to the weather. In other cases superficial scleritis is caused by rheumatism, gout, scrofula, menstrual derangements, and also appears without cause. It is probable that a patch of episcleral congestion may be maintained by insufficiency of the ocular muscle inserted in the neighborhood of its location.

In this form of superficial scleritis the *prognosis* is good so far as sight is concerned, because deeper and adjacent structures are uninvolved, but unfavorable on account of the recurrences.

**Treatment.**—This consists in the use of atropin to allay pain and prevent any tendency to iritis, warm antiseptic collyria, and hot compresses. In the chronic types eserin and pilocarpin have a beneficial influence, provided no iritis is present. Eserin may be employed in the strength of  $\frac{1}{4}$ — $\frac{1}{2}$  of a grain to the ounce; several drops three times a day—stronger solutions give rise to pain. Subconjunctival injections of salt solution are useful, and similar injections of salicylate of sodium (2 per cent.) and of hetol (cinnamate of sodium) have been recommended (Pflüger). Massage with a salve of the yellow oxid of mercury is indicated in chronic cases, and it has been recommended to scarify the tumefaction, scrape it away with a sharp curet, or cauterize it repeatedly, in a superficial manner, with the actual cautery. Internally, salicylic acid and iodid of potassium are needed in rheumatic cases, and good results follow diaphoresis with either pilocarpin or the Turkish bath. Menstrual and uterine disorders must be rectified. Any error of refraction or anomaly of the external eye muscles should be corrected.

**Fugacious Periodic Episcleritis.**—This name has recently been applied by Fuchs to a variety of relapsing episcleritis characterized by the appearance of one or more patches of episcleral injection or edema, of violaceous hue, lasting

from two to eight days, and reappearing again at intervals of several weeks or even months, to go through the same course. The duration of the affection is usually about one year; it occurs most frequently in adults. Gout and rheumatism are associated dyscrasias. The same affection was described some years ago by Swan M. Burnett under the name of "Vasomotor Dilatation of the Vessels," and by Jonathan Hutchinson with the title, "Hot Eye." The treatment is the same as that already recommended for episcleritis.

**Scleritis** may appear in the form of a *diffuse*, bluish-red injection, occupying the entire exposed portion of the sclera, very painful, unattended with secretion, save some increase in lachrimation, and liable to be mistaken for conjunctivitis or iritis; or in the form of *circumscribed* patches, of violaceous tint, situated in the ciliary region, and somewhat resembling in appearance the forms of superficial or episcleral elevations just described, being, however, less sharply defined, so that the whole zone may be involved, but in unequal degree. The chief distinction between the *superficial* and *deep* forms of scleral inflammation is the almost invariable tendency of the latter to affect other portions of the eye.

**Pathology.**—In episcleritis the infiltrating cells are found either in the superficial layers around the conjunctival vessels or in the deepest layers. The vessels are dilated, extravasations of blood are found, and often spots of necrosis and giant cells. Usually the choroid and sclera are infiltrated and edematous.

**Cause.**—The *causes* of deep scleritis are exposure to cold, rheumatism, gout, scrofula, vasomotor changes, and disturbances of the sexual apparatus, especially anomalies of menstruation. Syphilis may form the so-called *gummatous scleritis*, in which the patches are yellowish-brown and translucent; and gonorrhea, when this is associated with synovitis, may also cause the disorder. Finally, types of scleritis (sclerokeratitis) unassociated with any definite cause or diathesis are seen in young and middle-aged subjects, most commonly women, whose nutrition is depressed, and who may or may not have a scrofulous disposition or inheritance.

Deep scleritis usually attacks both eyes, runs a chronic course, and may affect the iris (leading to closure of the pupil), ciliary body, choroid, vitreous (causing opacities), and the cornea. In prolonged cases of the disease dark scars remain after absorption of the products of the inflammation, which are unable to resist the intra-ocular pressure, and form elevations (ectasia scleræ). Sometimes the whole anterior portion of the sclera becomes bluish or slaty-colored, is misshapen and elongated, and the cornea, which appears small, is poorly differentiated from it on account of the haziness of its margins.

**Sclerokerato-iritis** (*Scrofulous Scleritis*; *Anterior Choroiditis*).—This name is applied to the complicated scleritis referred to in the previous paragraph, and is characterized by chronicity, relapses, and involvement of the cornea and iris.

Beginning with a deep scleritis of the ciliary zone, the adjacent cornea becomes opaque and sometimes ulcerates; the iris is inflamed, posterior synechiæ form, and pain and congestion may be severe. After weeks the symptoms subside, the characteristic discolored area marks the former scleral disease, and haziness in the cornea indicates the seat of previous inflammation in this membrane. Then relapse takes place, with fresh scleritis, new corneal involvement, renewed iritis, or irido-choroiditis, and vitreous changes, and so on, until after many months, it may be, the disease comes to an end, leaving the sclera discolored and bulged, the cornea covered with patch-like opacities, the iris bound down with adhesions, the vitreous filled with opacities, and the eye practically deprived of vision.

*Sclerotizing keratitis*, referred to on page 317, is the name applied to a patch of opacity in the deeper corneal layers, usually triangular in shape, with its base toward the patch of scleritis which is its origin. After the cure of the scleritis, a white or yellowish-white opacity remains directly in contact with the sclera by its margin. Instead of a single patch of this character, several small triangular areas may arise in the circumference of the cornea as the result of scleritis.

**Treatment.**—The treatment of scleritis and sclerokerato-iritis depends upon the type and stage of the disease and the presence or absence of definite cause. It resembles that

already described with episcleritis. Locally, atropin, hot compresses, cocain, and boric acid lotion, and, in painful cases, leeches to the temple, are suitable. Pilocarpin is valuable if iritis is not present. The eyes should be carefully protected with goggles. After the subsidence of acute symptoms massage may be tried. The use of the actual cautery has been mentioned. Subconjunctival saline injections are useful.

In rheumatic cases salol, the salicylates, the alkalis, and iodid of potassium are the most available remedies; in gout, carefully regulated diet, mineral waters,—Buffalo, Poland, etc.,—citrate of lithium, colchicum, especially in the form of colchicin, and change of climate are useful. In scrofulous cases, cod-liver oil, iodin, iron, and sweats with pilocarpin (gr.  $\frac{1}{10}$  hypodermically) are indicated. The diaphoretic measures are proper in any case, other things being equal. In syphilis, bichlorid of mercury, and, if the nutrition permits, inunctions of mercurial ointment, are efficacious. Indeed, mercury is generally advantageous as a means of altering the nutrition of the part and preventing exudation into the uveal tract. Disorders of menstruation should always be corrected. Finally, in subjects with depressed nutrition, quinin, arsenic, and a general tonic regimen are required.

It is not always possible to distinguish between episcleritis and scleritis, unless the latter term be applied solely to those cases which involve structures other than the sclera itself; neither is it always possible in the early stages to say whether or not a patch of episcleral inflammation will develop into a serious type of the malady, or be temporary and abortive.

**Staphyloma of the sclera** has been divided by systematic writers into *anterior*, *equatorial*, and *posterior* staphyloma, according to the situation of the lesion. The last is not visible to the naked eye, but, by the findings of the ophthalmoscope, may be inferred to exist in a highly myopic eye (see page 159).

It is evident that all bulging of the sclera depends upon a disturbance between the resistance of the sclera and the intra-ocular tension, but it is not evident in all cases whether the process which originated the trouble began in the underlying tissue or in the scleral structure itself. There may be a gen-

eral enlargement of the scleral coat, as is seen in hydrophthalmos (page 321); or one or more darkly tinted swellings in the ciliary region may arise, one sometimes occurring in advance of each rectus tendon; or, finally, the staphylomatous swelling may exist at the equator in the region of the vena vorticosa.

The following *causes* may originate scleral staphyloma: Chronic glaucoma, old kerato-iritis and closure of the pupil, inflammation of the ciliary body, thinning of the scleral coat by repeated attacks of inflammation, tumors, and wounds closed by non-resisting scars.

**Treatment.**—A single scleral staphyloma may not destroy vision. If the intra-ocular tension is increased, an iridectomy is indicated. If the eye is useless, enucleation or one of its substitutes may be necessary.

**Abscess and ulcers of the sclera** are exceedingly uncommon, as the products of scleral inflammation rarely go on to suppuration or ulceration. Abscess in the scleral tissue may result from an infected wound and has been seen in connection with certain specific and contagious diseases—*e. g.*, glanders.

Ulcer of the episcleral tissue has been described with scrofula. A tumor, gumma, or tubercle of another region of the eye may break down and ulcerate into the sclera.

**Tumors of the sclera** are rare growths. The following have been seen: Fibroma, sarcoma, enchondroma, and osteoma.

The tissue of the sclera may be involved in a growth having its origin in a neighboring structure—*e. g.*, melanosarcoma of the ciliary body. Small primary scleral growths may be dissected from their beds and the wound closed with conjunctival sutures.

**Injuries of the Sclera.**—Wounds of the sclera may be inflicted with a sharp implement (knife, scissors, broken glass, etc.) or foreign body (chip of iron or steel, bullet, etc.), or they may result from a blow on the bulbus on the inner side and above, rarely downward and out, causing *rupture of the sclera*, usually found 3 mm. from, and concentric with, the corneal margin (T. Collins). The rupture may be exposed through a

rent in the conjunctiva, and is then said to be "compound," or it may be concealed by the conjunctiva, which is un torn. A blow may also *rupture the cornea*. Corneal tears, according to L. Müller, are more common in young people than scleral ruptures.

If the wound has *perforated* the sclera, two dangers at once present themselves: loss of a portion of the contents of the globe, with injury to the inner coats, and the introduction into the eye of septic material which will cause destructive inflammation.

**Symptoms.**—A perforating wound of the sclera, if sufficiently large, causes loss in the tension of the globe, hemorrhage into the vitreous, or, it may be, into the anterior chamber, and the appearance of dark tissue in the wound, representing, according to its situation, portions of the choroid, ciliary body, or iris, between which a bead of vitreous is likely to present. The diminution of intra-ocular tension may lead to the discovery of a small perforating scleral wound where the rent is obscured by the overlying contused and swollen conjunctiva. Rupture of the sclera is commonly associated with grave lesions in other portions of the eye—separation of the retina and extensive tears in the choroid and iris.

**Prognosis.**—This depends upon (1) the extent and situation of the wound and amount of escape of vitreous; (2) the presence or absence of septic material upon the implement or body which inflicted the injury; and (3) whether a foreign body has remained within the globe. From this it is evident that even a trifling perforating wound, unattended with loss of vitreous or prolapse of the inner coats, may be a point of entrance of infection.

**Treatment.**—Having determined, from the character of the implement, or by special examination, that no foreign body is within the globe, the eye should be carefully disinfected with a solution of bichlorid of mercury (1 : 5000), and the edges of the wound, after all foreign substances have been removed, penciled with a stronger solution of the same drug (1 : 2000). The overlying conjunctiva is then drawn together with several fine sutures. The eye is closed with an antiseptic com-



pressing bandage, and the patient is put to bed. Iced compresses are an advantage during the early stages of the treatment. At the end of forty-eight hours the wound may be inspected and the dressings renewed. In larger wounds the sutures (sterile silk or catgut) are passed directly through the sclera by some surgeons, care being taken to avoid the choroid, but the author agrees with Snell that scleral sutures are not necessary, conjunctival sutures being sufficient; usually the sutures may be removed at the end of a week, if the healing has progressed favorably. Some surgeons advise the introduction of iodoform before the application of the bandage. In some instances, in spite of kind healing of the scleral wound, there are subsequent detachment of the retina, vitreous change, and shrinking of the eyeball, but apparently hopeless cases may be saved by careful antiseptic surgery.

In the event of a scleral wound being extensive, with much loss of vitreous and collapse of the coats, especially if the ciliary body is involved and sight practically gone, or if the endeavors to remove the foreign body have been unsuccessful, enucleation should be performed to avoid the dangers of sympathetic inflammation in the fellow eye.

**Foreign Bodies.**—If the wounding substance has been small,—*e. g.*, a chip of steel, a splinter of glass, or a bullet,—endeavor should be made to ascertain whether this has penetrated the globe and remained within it, or has passed entirely through the eyeball and buried itself in the tissues of the orbit. Foreign bodies may be imbedded in any of the structures of the eye and are frequently found in the vitreous. If loose, they tend to gravitate to the lowest part of the vitreous and rest upon the posterior part of the ciliary body (T. Collins). According to Leber, perforating injuries of the eye with pieces of copper may result in purulent inflammation merely by the chemical action of the metal; if microbes are proved to be absent by culture experiments, an attempt to remove the body may be made, and, if successful, the eye saved, even if inflammation has begun. Foreign bodies may be tolerated for long periods of time, with good vision, in the background of the eye, but, according to Knapp, can never be trusted, unless

they are small and the accompanying changes trifling; under other circumstances they are liable to cause degenerative inflammation.

Unfortunately, the bleeding into the vitreous and anterior chamber, or damage to the lens, is apt to obscure the media to such a degree that ophthalmoscopic examination is not of much service; but if the media are clear, this may be the means of detecting the foreign body. An attempt at locating the body may be made by observing the situation of the wound, the probable direction which the foreign substance took on making its entrance, by a search for points of tenderness, and a scotoma in the field of vision. If there is any doubt, a skiagraphic examination should be undertaken, and in the majority of instances the Roentgen rays will readily reveal the presence and position of the foreign body. Of the various methods devised for this purpose, the one elaborated by W. M. Sweet, in the opinion of the author, is most satisfactory. The same is true of the method of McKenzie Davidson.

Having satisfied himself of the presence of a non-metallic foreign body within the globe, the surgeon may occasionally attempt to extract it through the original wound with delicate, carefully disinfected forceps, or through a new wound made in the most favorable situation.

If the foreign body is composed of iron or steel and its presence cannot be detected on account of opacities in the media, a diagnosis may be made, as was first suggested by T. R. Pooley, with the magnetic needle. Useful instruments have been constructed on this principle by Asmus and Hirschberg, and are known as *sideroscopes*. The giant magnet of Haab may be employed for the same purpose, the dislodgement of the foreign particle under its influence giving rise to a localized point of pain or spot of bulging, indicating its presence. An X-ray photograph made according to the method already noted, in the author's experience has never failed to give exact information of the position of the foreign substance. When this has been determined, the body should be extracted with an electromagnet, Hirschberg's instrument

being a most useful model. The extension point of the magnet is passed through the original entrance wound, or, if the case is not a recent one, through a wound made for the purpose. The disadvantage of this procedure is the introduction of an instrument into the vitreous; hence Haab's magnet is preferred by many surgeons, by means of which the foreign body may be drawn through the original wound, or, if this is not possible, from the vitreous into the anterior chamber, from which it is readily removed. The latter route has evident disadvantages, and hence it would seem preferable to the author, with the exact methods of localization which are now available, if the body cannot be made to pass through the original wound of entrance, that a new one, properly placed, should be made, to the lips of which the body can be drawn. Modifications of the Haab magnet, less powerful but also less bulky, have been devised by Lippincott, Johnson, Sweet, and others.

**Prognosis.**—This is always grave, but with the methods just detailed many eyes have been saved, and some with useful vision. The important point is to operate as soon as possible after the accident—*i. e.*, before the foreign substance has become incarcerated in the tissues and covered with lymph. As Coppez and Gunsberg point out, the prognosis is more favorable with those bodies which are situated in the vitreous than with those entangled in the ciliary body or choroid. If infection has already begun when the case is seen, the prognosis is usually hopeless and the eye should be enucleated. Van Millingen, however, has suggested trial of endocular cauterization under these circumstances—that is, the introduction into an infected scleral wound of a galvano-cautery point, if necessary even into the vitreous, and the cauterization of all surrounding tissue. If judicious efforts have failed to extract a foreign body from the interior of the eye, enucleation usually is necessary.

When a particle of iron remains for some time in the eye, there is a deposit of iron pigment in its tissues which gives rise to a condition known as *siderosis bulbi*, characterized by a peculiar greenish discoloration of the iris and lens.

**Congenital pigmentation of the sclera** (*melanosis*

*scleræ*) occurs both in spots and as a more diffuse discoloration. The spots are more common in the upper portion, and may be associated with pigment changes in the iris and choroid. Pigment spots in the sclera have been observed in certain diseases—*e.g.*, Addison's disease, and sometimes are exactly symmetric, situated near the margin of the cornea.

## CHAPTER IX

### DISEASES OF THE IRIS.

**Congenital Anomalies.**—*Heterophthalmos*, or the condition in which the color of one iris is different from that of the other, is a peculiarity in most instances without pathologic significance. It has been referred to on page 62.

*Corectopia*, a term applied to an eccentric position of the pupil, is not to be confounded with cases of true coloboma of the iris, presently to be described. The grade of corectopia may vary from a slight increase of the normal eccentric position of the pupil below and to the inner side, to those cases in which the whole pupil is displaced toward the border of the cornea. The latter variety is a very unusual phenomenon. This complete shifting of the normal position of the pupil has been ascribed either to an essential malformation or to the result of a fetal iritis. Both eyes may be affected symmetrically, and several members of the same family may present the defect.

*Polycoria*, or a multiplicity of pupils, is a rare anomaly. The abnormal pupil or pupils may be situated in the immediate neighborhood of the normal pupil, separated from one another by a narrow band of iris tissue, or the increased number of pupils may be the result of crossing strands of persisting pupillary membrane (Fig. 111). An opening which exists at the ciliary margin of the iris has been described, and is probably due to a *congenital iridodialysis*.

*Persistent pupillary membrane* results from an incomplete resolution of the membrane which covers the anterior surface of the lens during fetal life, and which usually disappears in the seventh month, although it may remain as late as the end of intra-uterine life, and even in the first month after birth.

Accurately speaking, it is more proper to regard the pupillary

membrane as a specialized portion of the *capsulopupillary* covering. The name of pupillary membrane alone is applicable to those cases in which threads attached to the small circle of the iris pass diametrically or cord-wise across the pupil, to be inserted elsewhere in the *corona* (Fig. 110). Usually the fibers proceed from the anterior surface of the iris across the pupil, either singly or in groups of three or more strands. Sometimes the fibers remain separated; sometimes they grow together in front of the anterior capsule or unite in the form of a variously colored plaque, adherent to the capsule of the lens (*capsulopupillary* membrane). Persistent pupillary membrane is more common in one than in both eyes; of 68 cases observed by Stephenson, 13 were bilateral and 55 unilateral.

Capsulopupillary tags are not infrequently mistaken for the

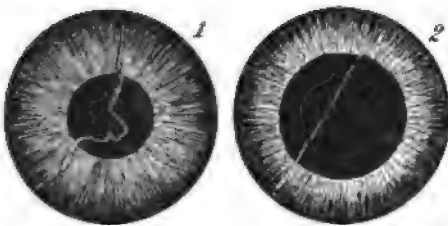


FIG. 110.—Persistent pupillary membrane: (1) Pupil contracted; (2) pupil dilated (Wickerkiewicz).



FIG. 111.—Polycoria.

synechiæ due to iritis; indeed, the association of the two has been observed. No difficulty, however, should arise, because the normal action of the pupil is not impeded by the presence of these vestigial anomalies. The appearance is not often detected until some other disorder calls for an ophthalmoscopic examination, because vision is not seriously or at all impaired. Oblique illumination will readily demonstrate the remains of pupillary membrane, and, indeed, is the best method with which to study this phenomenon.

*Coloboma of the iris* is a fissure of this membrane which in a general way resembles an artificial pupil made by iridectomy. The anomaly is more frequent in both eyes than in a single eye. When the defect is unilateral, the anomaly is usually found on the left side. The situation of the fissure is usually

downward or downward and inward. Exceptions to this rule have been observed; in very rare instances this coloboma is upward (Theobald).

The coloboma may extend across the whole iris (*complete coloboma*), or stop at a certain distance from the ciliary margin (*incomplete coloboma*). In addition, the so-called *pseudocoloboma* is described, which may be looked upon as a form of heterochromia of the iris, or indicates the last remains of the ocular fissure which is tending toward closure, and which appears as a small stripe, somewhat granular, and differentiated from the rest of the iris by its brighter color. In "bridge coloboma" the borders of the cleft are united by a narrow pigmented or colorless band of fibers.

Coloboma of the iris is frequently associated with similar defects in the choroid, and also with microphthalmos, congenital cataract, fissure of the eyelids, lips, and palate. Its probable cause is an arrest of development, the result of incomplete closure of the *choroidal fissure*. Much evidence has been brought to show hereditary tendency in this defect.

*Irideremia*, or congenital absence of the iris, occurs both in a *partial* and a *complete* form. The appearance somewhat resembles an eye with complete mydriasis.

Total congenital irideremia is almost invariably bilateral. It is frequently associated with other anomalies of the globe—partial or complete cataract, dislocation of the lens, nystagmus, strabismus, departures from the normal curvature of the cornea, or annular opacities in its periphery. In a majority of instances there is a marked hereditary tendency.

*Congenital ectropion of the uvea* consists in a round mass of dark color projecting from the margin of the pupil, bending around to the anterior border of the iris. A similar formation is proper to the eye of the horse and is frequently seen in the cow. This appearance has sometimes been described as a *papilloma of the iris*; it is not, however, a neoplasm, but a congenital ectropion of the uvea.

*Cysts, nevi, and atrophies of the iris* occur as congenital defects.

**Functional Motor Disorders of the Iris.**—Under this

heading may be mentioned *mydriasis*, or dilatation of the pupil; *myosis*, or contraction of the pupil; *lippus*, or alternate contraction and dilatation of the pupil (see also page 68). *Iridodonesis*, or tremulous iris, or an oscillation of the iris depending upon want of support, as, for instance, in dislocation of the lens, although not a functional motor disturbance of the iris, is conveniently mentioned in this connection.

**Hyperemia of the iris** is associated with several acute affections of the eye, for example, acute trachoma, purulent conjunctivitis, keratitis, scleritis, inflammations of the uveal tract, and traumas, and is a precursor of inflammation. Hence it is a symptom rather than a special disease of the iris itself.

Hyperemia of the iris is recognized by change in color, a blue iris becoming greenish, a brown iris reddish-brown; by contraction of the pupil, which dilates sluggishly or not at all, to the changes of shade and light, and is slowly affected by a mydriatic, the effects of which are much less permanent than in the healthy iris; and by slight pericorneal injection.

The *treatment* consists in the management of the disease which has caused the hyperemia, and especially in the instillation of atropin.

**Iritis.**—Under the general term *iritis* are included various types of inflammation of the iris which may be—(1) Idiopathic; (2) symptomatic of disorders in other portions of the eye, or of disease in the general constitution; and (3) traumatic.

**Symptoms.**—1. *Change in the color* of the iris, in addition to loss of its natural luster and obscuration of the characteristic striated appearance.

2. *Pericorneal injection*, due to congestion of the non-perforating branches of the ciliary vessels (System II.), producing the fine pink zone surrounding the cornea known as “ciliary congestion,” or the “circumcorneal zone.” In severe cases there may be distention of the posterior conjunctival vessels, and slight chemosis of the conjunctiva (see also page 58).

3. *Myosis*, or contraction of the pupil, due partly to hyperemia, and partly to irritation of the peripheral nerve filaments.



The reaction of the pupil to the influence of light and mydriatics is diminished or lost.

4. *The formation of posterior synechiæ*, or inflammatory attachments between the iris and the capsule of the lens. These may be suspected when the pupil fails to change its diameter under the varying influence of light and shade, and are demonstrable by the instillation of a mydriatic, which will produce an irregular dilatation of the pupil, certain portions of the pupillary margin of the iris being held back by somewhat tongue-shaped projections attached to the lens-capsule.

The attachments may vary in size, firmness, and number; being either narrow and thread-like, broad and dense, single or multiple, or even extending all around and pinning down

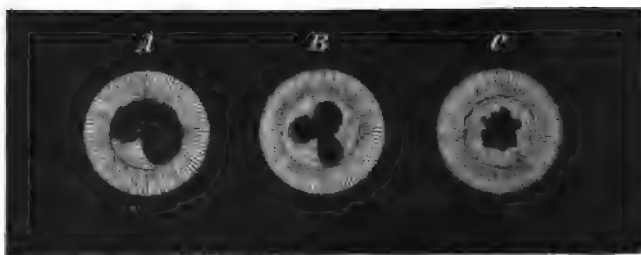


FIG. 112.—Various forms of posterior synechiæ: *A*, Single attachment; *B*, multiple attachment forming the so-called "ace-of-clubs" pupil; *C*, irregular annular attachments (Sichel).

the margin of the iris in an annular manner. In association with the synechiæ there may be an exudate of false membrane covering the whole pupillary space.

5. *Irregularities in the surface of the iris*, due to local swellings, accumulations of exudate, or the formation of nodules.

6. *Haziness of the cornea* or deposits upon its posterior surface. According to Friedenwald, the cornea is affected in every case of iritis, either with deposits on Descemet's membrane or infiltrations in the substantia propria. The former are constant, the latter occasional.

7. *Change in the character of the aqueous humor*—(1) Slight or considerable turbidity; (2) pus; (3) blood; and (4) occasionally exudate.

In addition to the symptoms just detailed there are *subjective* signs more or less peculiar to iritis.

1. *Pain*.—This is situated first in the eyeball, and is known as "ciliary pain," and second in the brow and temple, sometimes quite sharply defined in the distribution of the supra-orbital nerve, very severe, throbbing and stabbing in character, and with marked increase in severity during the night. Occasionally the nasal and infra-orbital regions are the painful areas.

2. *Disturbance of Vision*.—This is in direct proportion to the amount of cloudiness which has occurred in the media. Very great impairment of visual acuity denotes extension of the disease to the ciliary body or deeper structures.

During iritis, transient myopia and astigmatism are commonly present. Especially in the plastic types of the disease, even after full pupillary dilatation, an increase in the refractive power is demonstrable. Although there are changes in the corneal curvature, according to Oliver the bulk of the ametropic change in such cases is due to perversion of the lens action from *spastic accommodation* (Koller) as the result of ciliary irritation.

3. *Tenderness of the Globe*.—This occurs even in uncomplicated iritis, especially of rheumatic origin, but if severe, suggests inflammation of the ciliary body.

4. *Photophobia and Lacrimation*.—These symptoms vary considerably in degree, being almost or quite absent in some varieties, and severe in those of acute and violent onset.

5. *Malaise*, fever, nausea, and marked depression occasionally are experienced by the patient, the last often being the result of prolonged pain and insomnia.

**Diagnosis**.—The salient symptoms of iritis just detailed are sufficient for the purpose of diagnosis; nevertheless, it is not uncommon to find a case of iritis mistaken for some other external inflammation, and valuable time is lost by the useless application of astringent remedies. Most commonly, cases of simple iritis have been mistaken for one or the other types of conjunctivitis, and the following table may be found useful:

IRITIS.	SIMPLE CONJUNCTIVITIS.	PHLYCTENULAR CONJUNCTIVITIS.
1. Severe brow pain, worse at night.	Feeling of foreign body in the eye.	Acute general irritation.
2. Dim vision.	Vision usually unimpaired, unless secretion is very abundant.	Vision impaired by corneal involvement.
3. Fine pericorneal injection.	Coarse conjunctival injection.	Diffuse injection, with special lines of vessels running to phlyctenules.
4. Absence of secretion; some abnormal lachrimation.	Mucopurulent discharge; flakes of lymph.	Free lachrimation.
5. Sluggish or immobile pupil.	Pupil unaffected.	Pupil unaffected.
6. Iris discolored.	Iris unaffected in color.	Iris unaffected in color.
7. Abnormal reaction to mydriatic.	Normal reaction to mydriatic.	Normal reaction to mydriatic.
8. Severe photophobia exceptional.	Several photophobia absent in simple cases.	Severe photophobia and blepharospasm.
9. Conjunctiva usually translucent; occasionally chemotic.	Conjunctiva opaque, velvety, and at times chemotic.	Conjunctiva translucent, bathed in tears.
10. Slight tenderness on pressure.	Tenderness not marked.	Tenderness not marked.
11. Posterior synechiæ.	No synechiæ.	No synechiæ.

Many variations in the types of iritis make it impossible to formulate unvarying rules for the establishment of a differential diagnosis, but attention to these points may prevent mistakes.

A diffuse scleritis somewhat resembles in its color the zone of pericorneal injection more or less characteristic of iritis, which, indeed, may be a complicating symptom of this disease. Acute glaucoma bears some resemblance to acute iritis (for the distinguishing points see page 419).

**Course, Complications, and Prognosis.**—An iritis may pursue an acute course, reaching its termination in four to eight weeks, or be chronic from its onset and last, in a slow and insidious inflammation, for long periods of time. The termination of an iritis may be entirely favorable. The inflammatory adhesions disappear, and the iris regains complete mobility, only a few traces of iris pigment being seen on the capsule of the lens. On the other hand, more or less complete attach-

ment causing distortion and inequality of the pupil (consult Fig. 112) may remain; or deposits of exudate may directly occlude the pupil and lie upon the capsule of the lens.

The binding down of the iris throughout the whole extent of its pupillary edge, although the pupil itself remains clear, is denominated *exclusion of the pupil*; if the pupil is filled in with opaque inflammatory deposit, the term *occlusion of the pupil* is applied. With extensive or annular synechiæ the angle of the anterior chamber becomes obliterated, the iris is bulged forward except around its pupillary margin, which is bound down, so that a crater-like depression is evident, and

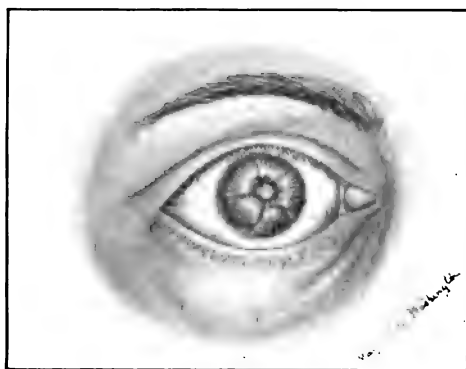


FIG. 113.—Exclusion and occlusion of pupil with exudate behind iris, following gummatous iritis; compare with Fig. 114 (from a patient in the Philadelphia Hospital).

the appearance denominated "*iris bombé*" is developed. This leads to increased tension, secondary glaucoma, and even detachment of the retina, unless the communication between the anterior and posterior chambers of the eye is restored by operative measures (Figs. 113 and 114).

The following tissues of the eyes may become involved during the course of an iritis: The cornea (*keratitis punctata*); the ciliary body (*iridocyclitis*); the choroid (*iridochoroiditis*); the vitreous (*hyalitis*); and the optic nerve and retina (*hyperemia* or *neurorretinitis*). With these facts in mind, and with the tendency of certain types of the disease to relapse, a prognosis must be guarded, but in uncomplicated iritis, seen early

and properly treated, a perfect result may be obtained in the large majority of cases.

**Pathology.**—Systematic writers have divided iritis into three

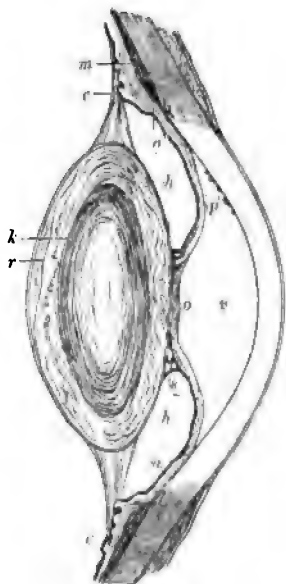


FIG. 114.—Exclusion and occlusion of the pupil. The iris is adherent by its entire pupillary margin to the lens. The posterior chamber (*k*) is thus made deeper, the anterior chamber (*v*) shallower, especially where the root of the iris (*a*) is pressed against the cornea. The retinal pigment is beginning to separate at *s*. The pupil is closed by an exudate membrane, *o*. In the lower part of the anterior chamber there is matter (*p*) precipitated upon the posterior surface of the cornea. The cortex of the lens has become cataractous (*r*); the nucleus (*k*) is unaltered (Fuchs).

varieties, *plastic*, *parenchymatous*, and *serous* iritis. In general terms, however, it may be said that the iris is thickened and infiltrated with round cells, which are collected either along the line of the vessels or in circumscribed nodules. The vessel-walls are thickened, and small hemorrhages occur in the tissue. The exudate in the anterior chamber consists of round cells, mixed with fibrin and pigment granules. In light cases the inflammatory products are completely absorbed, but when more abundant, they organize, forming a layer of connective tissue which covers the iris and binds it to the lens, occluding the pupil in the manner already described. The exudate in the iris likewise organizes, and the atrophic iris shows obliterated and thickened vessels, clumping of pigment granules, and an entire absence of iris-stroma. *Purulent* iritis due to infection with micro-organisms is followed by panophthalmitis.

Iritis has also been divided, according to its character and course, into *acute* and *chronic* iritis, and according to its supposed etiology, into *syphilitic*, *rheumatic*, *gouty*, *gonorrheal*, *diabetic*, *tubercular*, *scrofulous*, *cachectic*, *idiopathic*, *traumatic*, *sympathetic*, and *secondary* iritis.

**Treatment.**—This depends upon several indications: (1) The suppression of pain by warm fomentations or dry heat, local blood-letting, and the internal administration of analgesics. (2) The maintenance of mydriasis by atropin or other mydriatics. (3) The recognition of the cause and the exhibition of suitable internal medication, as well as the administration of remedies having the general physiologic action of alteratives, even if the exact cause cannot be ascertained. (4) The use of surgical interference according to the indications. The description of the treatment in detail is reserved for the subsequent sections devoted to the particular consideration of the various types of iritis which follow.

**Plastic iritis** runs an acute, subacute, or chronic course, and is the most common form of the disease. The salient symptoms of iritis are present: discoloration of the iris, pericorneal injection, immobility of the pupil, and posterior synechiæ.

Not only may the ordinary attachments form between the iris and the capsule of the lens, but a plastic exudate may cover the pupil-space with a false membrane, and in some cases a gelatin-like mass is deposited in the anterior chamber. When this material consolidates, its appearance has been compared by Schmidt-Rimpler to that of a dislocated lens in the same position (*fibrinous* or *spongy iritis*). Plastic iritis is seen in—

1. *Syphilis*—*Syphilitic Plastic Iritis*.—When plastic iritis appears in the early stages of general syphilis or in the stages of the mild exanthematous manifestations (the condylomas and the inflammations of the mucous membranes), it is not accompanied by characteristic clinical symptoms, which of themselves justify the diagnosis of syphilis.

The percentage of cases of syphilis which acquire iritis during the course of the disease varies from 0.42 to 5.37 according to different authorities; but among cases of iritis syphilis has been found to be the cause in from 30 to 60 per cent. (Alexander).

This form of iritis is common between the second and ninth month after the initial lesion, but may be delayed until

the eighteenth month. Some authors have placed the appearance of plastic iritis in the gummatous stage of syphilis, but it is more probable that in such cases a few synechiæ, remaining from a plastic iritis in the early stages, have caused a relapse in this late period.

Commonly both eyes are attacked, one a little later than its fellow; occasionally the onset is simultaneous. The course usually is acute, and after *thorough* cure relapses are not common. A subacute or chronic type is also described.

Acute iritis of the plastic type is rare in new-born infants of syphilitic heritage, but has been described in children with inherited syphilis, from the second to the fifteenth month. Acute iritis in children in the first months of life, and also in the later childhood years, usually is the result of hereditary syphilis; a late manifestation may assume the serous type of the disease. In addition to the symptoms of severe plastic iritis secondary involvement of the vitreous and ciliary body is liable to take place.<sup>1</sup>

**Treatment.**—The most important local drug in this, as in other forms of iritis, is atropin (gr. iv- $\frac{1}{2}$ ), several drops to be instilled in the conjunctival cul-de-sac every three or four hours. Mydriasis should be maintained until all ciliary irritation has subsided and during the period of changes in the refractive power of the eye (see page 343).

Pain is relieved and at the same time congestion is diminished, thus rendering the mydriatic action of the atropin more certain, by leeching the temple—one to three Swedish leeches being applied near the line of the hair, or blood is drawn by an artificial leech. In the absence of a regular Heurteloup this may be accomplished by making an incision in the temple with a scalpel and using a small cupping-glass, to which a piston is attached for exhausting the air. Should atropin not be tolerated, hyoscyamin, hyoscin, scopolamin, or duboisin may be substituted. Their mydriatic effect is increased by the addition of cocain.

<sup>1</sup> Some authorities hold that in syphilitic iritis change in the parenchyma of the iris with the formation of small nodes, in some instances indistinguishable by ordinary methods, is always present.

The constant use of atropin leads to disagreeable dryness of the throat. This may be obviated in part by compressing the tear-duct after each application. It may be relieved by giving the patient a gargle made of equal parts of iced water and a strong decoction of coffee. Small doses of morphin are said to be of service, and pilocarpin and pellitory lozenges are useful.

Pain is further relieved by the application of moist or dry heat ; the latter is best made by means of cotton batting which is held before a fire and then laid upon the affected eye, to be replaced by a freshly heated mass as soon as cooling occurs, or with a Japanese stove or hot box. Moist hot applications are more efficient if a pad of surgical gauze is steeped in the following solution : Acetate of lead, ʒj ; powdered opium, ʒss ; boiling water, Oj (Randolph).

The best constitutional treatment is some form of mercury, either the protiodid, blue mass, or calomel, given, as in syphilis generally, just short of the point of salivation, and continued for many weeks even after all acute symptoms have subsided. When it is important to obtain rapid mercurial action, inunctions are advantageously employed. Hypodermic injections of mercury, particularly mercuric chlorid, are strongly advocated by some surgeons. During the time that mercury is being pushed to the point of tolerance, the gums must be carefully watched for signs of sponginess, and the patient should frequently use a chlorate of potassium mouth-wash.

After the course of mercury, iodid of potassium is indicated, for its own effect and for eliminating the mercury ; later this may be combined with the bichlorid of mercury.

In old syphilitics, with much cachexia, in whom a plastic iritis improperly treated in the early period has relapsed, it is not always wise or possible to induce active mercurialization. For them bichlorid combined with the tincture of iron is a suitable remedy. Subconjunctival injections of bichlorid of mercury (2 to 4 drops of a 1 : 2000 solution), advocated by Darier and others, are efficient, but painful. Equally good results are obtained with 5- to 15-minim injections of physiologic salt solution, and, if there is not too much circulatory



stasis, represent a most efficient therapeutic measure. The injections may be given every second or third day, and should be followed by light massage of the eyeball.

2. *Rheumatism—Rheumatic Iritis.*—This disease occasions iritis of a plastic form, or rather, rheumatism is a predisposing cause of many cases of iritis, in the opinion of some authors (Berry) the rheumatic form being the most common of all the types.

It occurs between the ages of twenty and fifty, either with or without coincident rheumatic affections, and varies considerably in the aggressiveness of its symptoms. Not uncommonly these are severe, with much pericorneal injection, acute pain, greater usually than in syphilitic cases, and tenderness of the globe. Most frequently one eye is affected; the inflammation rarely is simultaneously symmetric. The second iris becomes inflamed after a longer or shorter interval.

Relapses are frequent, in this particular differing from syphilitic plastic iritis, and a patient once having had an attack of rheumatic iritis is liable at intervals of months or even years again to be attacked. If treatment is begun early, even in recurring attacks, perfect cure may be expected, as extensive exudation of lymph is uncommon.

The frequent relapses of rheumatic cases have given rise to the term *recurrent iritis*, applicable to some varieties.

A form of plastic iritis exists, aptly called "*quiet iritis*" (Hutchinson), in which there is no pain nor ciliary congestion, the only symptom being the progressive dimness of vision which leads to its discovery, and which is caused by rheumatism or inherited arthritic tendency in a majority of cases, but which may also depend upon syphilis. A form of quiet iritis in which the lesions are said to be confined to the posterior layer of the iris has been described by Grandclément under the name "*Uvéite irienne.*"

**Treatment.**—The use of atropin in the manner already described is of paramount importance. Leeches and moist and dry heat will help to relieve the pain, and, at the proper stage, subconjunctival injections of salt solution. Frequently these measures will not be sufficient, and morphin or codein may be

administered. Much comfort often results from the administration at night of  $\frac{1}{100}$  of a grain of hyoscin. Rubbing the brow with an ointment of mercury and belladonna is of some service.

Antirheumatic remedies are of great importance, and much reliance may be placed upon salicylic acid, salicylate of sodium, oil of gaultheria, and the alkalis, the last, in the form of the *mistura potassii citratis*, being advantageously combined with tincture of aconite if restlessness and fever are associated symptoms. Of these remedies salicylate of sodium is the best; indeed, it relieves the pain of any form of iritis. It should be exhibited in full doses, 60 to 80 grains during the first twenty-four hours, and then the amount gradually lessened.

The tendency of rheumatic iritis to recur requires preventive treatment in the form of regulated diet, the use of mineral waters, and proper attention to change of clothing according to the vicissitudes of the climate.

In rheumatic iritis which has assumed a chronic type, or if there has been exudation of lymph or involvement of the ciliary body, mercury may be exhibited to obtain its alterative effect; for the same reason iodid of potassium is required.

3. *Gout—Gouty Iritis*.—This resembles rheumatic iritis in its tendency to relapse and to attack one eye at a time. An iritis may reveal a gouty diathesis previously latent and unsuspected, and may appear as the first symptom of this affection, to be followed by an outbreak of gout elsewhere in the body.

A form of iritis, insidious in character and destructive in tendency, almost invariably associated with disease of the vitreous, occasionally occurs in children of gouty parents. These children, according to Mr. Hutchinson, have a peculiar squareness of build, heavy features, florid complexions, and feebleness of circulation in the extremities.

**Treatment.**—The usual measures to relieve pain and maintain mydriasis are indicated, together with appropriate anti-gout diet, citrate of lithium, salicylate of lithium, colchicum, iodid of potassium, and hypodermics of pilocarpin. Change of climate may be necessary. In the chronic cases tonics are suitable remedies.

4. *Gonorrhea—Gonorrheal Iritis*.—This is a form of iritis,

chiefly plastic in character, which usually does not coincide with nor immediately follow the gonorrheal attack; an arthritis of the knee, or sometimes of the ankle, intervenes. Sometimes it occurs with the gonorrhea, and Brailey has seen it assume a gelatinous type. In the author's experience gonorrheal iritis is more common than has usually been supposed. It has been explained by the influence of the gonococci on the iris. Like the rheumatic types, it is attended with severe pain, in addition to the usual symptoms of iritis. It may relapse with each new attack of gonorrhea.

**Treatment.**—The local use of atropin, etc. If the urethra is inflamed, this must receive attention. Iodid of potassium may be tried, and mercury, if there is much exudate. Relief will follow profuse sweats by means of pilocarpin given hypodermically or in the form of the fluid extract of jaborandi; indeed, these remedies are of great value in other varieties of stubborn iritis. Subconjunctival injections of salt are efficient.

5. *Diabetes—Diabetic Iritis.*—The subjects of diabetes may develop a plastic iritis, not only after an operation involving mutilation of the iris, but independently of any exciting cause. The disease is intractable and sometimes is complicated with hemorrhage into the anterior chamber. On account of the occasional association of diabetes and iritis, an examination of the urine is advisable in all cases of stubborn iritis.

**Treatment.**—This requires the usual local remedies for iritis and the treatment suited to diabetes.

**Parenchymatous iritis** is characterized by general or localized discoloration or swelling of the iris, owing to inflammation and cellular proliferation within its tissues.

The swelling may be general and the margin of the pupil tied down to the capsule of the lens by exudation; or small yellowish nodosities, crossed by vessels near their free borders, rise perceptibly above the level of the iris, and gradually shade away into its structure. The effusion into the parenchyma of the iris may become purulent, with filling up of the pupillary space and the formation of hypopyon. Parenchymatous iritis is seen in—

1. *Syphilis—Syphilitic Parenchymatous Iritis; Iritis Papu-*

*losa*; *Gummatous Iritis*.—In the later secondary stage of syphilis a form of iritis occurs, differing from the plastic variety by the development of clinical features, characteristic of the disorder which has produced it.

This is indicated by the appearance in the inflamed iris, if it occurs during the course of a plastic iritis, or independently of this antecedent condition, of one or more yellowish, reddish-yellow, or reddish-brown nodules, varying in size from a hempseed to a small pea, situated at the pupillary or ciliary border, or occasionally between the two, in the iris tissue. They are crossed by fine vessels. They vary in number from one to

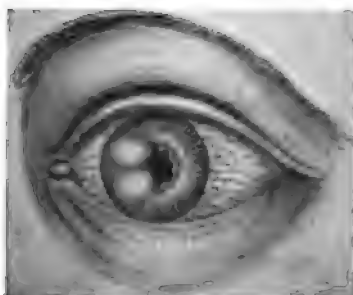


FIG. 115.—Gummatous iris (from a patient in the Philadelphia Hospital).

four, the intervening iris tissue being comparatively unaffected, and belong, in spite of their resemblance to gummas, to a comparatively early period of syphilis. They are gradually absorbed without leaving distinct scars or atrophy of the iris tissue to mark their former situation.

This is the so-called *gummatous iritis*, although some writers (Alexander) reserve this name for the formation of true gumma of the iris, and describe the present type as *iritis papulosa*.

*Gumma of the iris*, according to Alexander, appears almost constantly at the ciliary border, is solitary, of the size of a pea or small nut, grows toward the ciliary body, and disappears through fatty degeneration, leaving behind a permanent scar or atrophy of the iris. This appears in the so-called tertiary period of syphilis, or that period in which gummas in other organs are found.

The disease known under the name of "gummatous iritis," or sometimes "true syphilitic iritis," is not common; Alexander, however, states that in more than 27 per cent. of iritis he has found that form of iris change which is described by the general term "iritis gummosa."

**Treatment.**—The same treatment described in connection with syphilitic plastic iritis is applicable, and mercury should be pushed until complete absorption of the nodes has been obtained.

In true gumma of the iris, on the other hand, the free use of mercury is not always permissible, owing to the cachectic state of the patient, and because more rapid absorption appears to take place under ascending doses of iodid of potassium.

**Scrofulous iritis** occurs usually in children and young persons of scrofulous habit. In some respects it resembles inherited syphilitic iritis. Nodules of lardaceous appearance may also form. *Tubercular iritis* is described on page 358.

**Infectious disease iritis** is seen in association with recurrent fever, pneumonia, cerebrospinal meningitis, influenza, typhus and typhoid fever, and a *purulent iritis*, as the result of embolism, occurs in the course of septicemia after puerperal fever, and in pyemia.

In malaria a *periodic iritis* with hypopyon has been described, and somewhat analogous to this is another periodic iritis, or iridocyclitis, which has been seen before each menstrual period (*iritis catamenalis*), perhaps due to abnormalities in the uterine discharge. Iritis due to *dental irritation* has been described by B. L. Millikin, and to nasal suppuration by Ziem.

The management of such cases depends upon general principles, the free use of quinin and stimulants being appropriate in purulent iritis.

**Idiopathic iritis**, or one in which no local injury or constitutional disease can be accredited with its origin, is rare in elderly people, occurs in adults, chiefly men, and has been described in children in a slight plastic form, especially in girls nearing puberty.

Idiopathic iritis has been ascribed to cold, but often no cause can be given; it usually is monolateral.

**Traumatic iritis** occurs as the result of an injury, either accidentally inflicted or made in the course of an operation—*e.g.*, cataract extraction.<sup>1</sup> In this category are placed, also, those cases of iritis which follow dissection of the lens and which depend upon swelling of the cortical material or upon infection conveyed through the wound. Parenchymatous iritis will follow injections of *staphylococcus aureus* into the anterior chambers of rabbits.

**Treatment.**—The usual local measures are advisable, and if the inflammation is seen in the first stage of its development, iced compresses are suitable, for the same reason that they are applicable in wounds of the eyeball generally. These must not be used late in the disorder, nor in any other form of iritis.

**Sympathetic iritis** (see page 371).

**Secondary iritis**, or that form which appears with other diseases of the eye by the spread of the inflammation, is most commonly seen in association with diseases of the cornea which present themselves in the form of sloughing or perforating ulcers, and has been described in this connection. Scleritis of the deep variety is often associated with iritis.

More rarely the primary disease begins deep in the eye—*e.g.*, by detachment of the retina. The pressure of intra-ocular tumors or vitreous exudates may occasion a secondary iritis.

**Serous Iritis** (*Descemetitis; Aquo-Capsulitis; Keratitis Punctata; Serous Cyclitis*).—This affection has been described in part on page 314, and is characterized by a serous or more commonly a seroplastic exudate, deepening of the anterior chamber, slight dilatation of the pupil (at least an uncontracted pupil), haziness of the cornea and aqueous humor, and a precipitate of opaque dots upon the posterior elastic lamina of the cornea, generally arranged in a triangular manner, with the apex pointing upward. There is a slight pericorneal injection, at first no great tendency to form synechiæ, and the tension is apt to be higher than normal, at first, but

<sup>1</sup> Spongy iritis (page 347) is occasionally seen after cataract extraction (Knapp). Strong solutions of eserine may produce plastic iritis (*eserin iritis*).

later diminishes. Posterior synechiæ form later, and if they are extensive, secondary glaucoma.

In serous iritis Collins has found pathologic changes in the glands of the ciliary body, and hence the recommendation of Priestley Smith that this disease be designated *serous cyclitis* is appropriate. In *serous iridocyclitis* Groenouw has demonstrated round-cell infiltration of the iris, of the deeper layers of the corneal border, and the ciliary body. There were collections of round cells on the posterior layer of the cornea and on the ciliary processes. The choroid, retina, and optic nerve were normal.

Serous iritis often, indeed, usually is seen in association with disease of other portions of the eye, and appears as one of the manifestations of sympathetic ophthalmitis (page 371). It may arise, like the other forms of iritis, from a true syphilitic basis in the early stages of this disease (Alexander), or as a late manifestation, the average time being thirteen years after infection (Brailey). It is more common in women than in men. It is often observed with menstrual and pelvic disorders in anemic patients, and also with rheumatism and gout.

**Treatment.**—The rule, previously given, to maintain complete mydriasis with atropin, meets with an exception in this type of iritis. The drug must be applied with great caution, a continual watch being kept on the tension. Diuretics, laxatives, and diaphoretics are indicated. Iodid of potassium acts well. Should a syphilitic origin be determined upon, the usual remedies are applicable. Persisting rise of intra-ocular tension may be overcome by paracentesis corneæ; or if this fails and the increased intra-ocular tension continues, an iridectomy may be required.

**Chronic Iritis.**—Any type of iritis may assume an acute, subacute, or chronic course; if the last, no additional symptoms occur, but those ordinarily present are modified by the chronicity of the stages.

In addition to the chronic type of an ordinary iritis there remains to be described one which has received the name *plastic iridochoroiditis*, because of co-existing disease of the choroid and vitreous, leading to the formation of a sec-

ondary cataract. This disease occurs in adults, usually without assignable cause, is symmetric, and proceeds steadily in a tendency destructive to the nutrition of the eye (see also page 367).

The *treatment* of the latter condition is unsatisfactory, alteratives, tonics, and operative measures often meeting with indifferent success.

**Operative Treatment in Iritis.**—Paracentesis of the cornea, as before noted, may be needed to reduce continued elevation of tension in some forms of iritis. Should inflammation of the iris and hypopyon exist, the treatment already described (page 295) is required.

An iridectomy may be needed in recurrent iritis, or in an iritis which refuses to heal completely, some ciliary injection and irritability remaining. Those cases which present the least change in the iris, in which the aqueous humor is clear and the tension is not subnormal, are most likely to yield a good result. Iridectomy in recurrent iritis of rheumatic type does not insure the patient against future attacks.

In chronic iritis circular posterior synechiæ and bulging of the iris are the most important indications for the operation. Determined rise of tension and threatening glaucoma, under any circumstances, furnish reasons for its performance. According to Nettleship, keratitis punctata, chronic thickening of the iris with very extensive attachments, the existence of myopia, a tendency to spontaneous bleeding, and hypopyon render the operation less desirable; if the tension is below the normal, the operation may be followed by bleeding and shrinking of the eyeball.

An iridectomy is performed to secure one or all of three ends: (1) Prevention of recurring attacks; (2) reestablishment of the communication between the anterior and posterior chambers of the eye, and thereby improvement in nutrition and aversion of threatened glaucoma; (3) improvement in vision by the substitution of an artificial pupil for one that has been occluded or excluded.

The point for the operation must be determined in large measure by the condition of the iris, that portion being se-



lected for excision which is least changed and least bound down by adhesions.

Before operating great care should be exercised to note the tension, the state of the iris, and, if possible, of the deeper structures, and to obtain a map of the field of vision. If these examinations indicate much deep disease, strong reasons are present for declining to operate.

Posterior synechiæ remaining after the acute symptoms of iritis have subsided have been regarded as a cause of relapse or recurrence, and, although this has not been proved, several operations have been devised for severing such attachments, to which the general term *corelysis* has been applied.

**Tumors of the Iris.—Cysts.**—Cysts, having transparent, delicate walls lined with pavement epithelium (*serous cysts*) may be congenital or may develop in the iris as the result of an injury. Traumatic cysts, which owe their origin to the intrusion through a wound of corneoconjunctival epithelium, which proliferates, are divided by J. Meller into *iris-cysts proper*, which are situated entirely within the iris tissue, *iris-chamber cysts*, which are situated partly in the iris and partly in the anterior chamber, and *wall-chamber cysts*, which are so situated that the iris forms only part of their boundary wall. *Retention-cysts* may arise from closure of the crypts of the iris. Implantation of a cilium in the anterior chamber may be the starting-point of an *epithelial, pearl-like tumor* (*pearl-cysts* or *cholesteatoma*), essentially cystic, with a lining of laminated epithelium and semisolid contents of degenerated epithelial cells and fat-globules (F. R. Cross and E. T. Collins).

A cyst may be minute, or grow and fill the anterior chamber; both eyes may be affected, and some instances of multiple iris-cysts are on record. A cyst may cause iridochoroiditis and sympathetic ophthalmitis by pressure. An attempt should be made to remove it through an incision, the growth and surrounding iris being seized, drawn out, and excised.

**Tubercle of the Iris (*Tubercular Iritis*).**—In a certain number of cases, usually between the ages of five and twenty-five (Pechin), small, grayish-red nodules develop at the margin of the pupil, bearing great similarity in their external appearance

to miliary growths. Such growths may disappear, posterior synechiæ remaining at their points of origin, or successive developments of new nodules may lead to a plastic inflammation of the iris and ciliary body and shrinking of the eyeball. Under these circumstances tubercle of the iris appears in the form of an iritis.<sup>1</sup>

Tubercle of the iris also occurs in a *solitary form*, a yellowish nodule growing from the periphery of the iris, covered, it may be, with smaller bodies.

The average age of persons affected with primary tuberculosis of the iris is twelve years; one or both eyes may be affected, more commonly the former. Although the patients may present no other signs of tuberculosis, this, and in a fatal form, may become a sequence. Sometimes the infection of the iris is secondary to the general disease. Bacilli and giant-cells are found in these growths, proving their true nature. If operation is undertaken, it should be the removal of the entire globe; iridectomy has been almost uniformly unsuccessful. The introduction of iodoform into the anterior chamber has been tried.

**Sarcoma of the iris** is rare as a primary disease. It is usually pigmented. At first of slow growth, later it increases rapidly, with pain, hemorrhage, etc., and finally bursts forward through rupture of the globe. It is most common in females (of 46 cases collected by Veasey, there were 14 males and 32 females), and usually occurs between twenty and forty, the average age being about forty years; the lower part of the iris is generally affected.

An exceedingly rare tumor is the non-pigmented iris sarcoma (*leukosarcoma*). This may be complicated with serous iritis.

In the early stages, when the growth is circumscribed, favorable results follow excision of the diseased portion of the iris; later enucleation of the globe is necessary.

<sup>1</sup> In the opinion of certain authors these small tumors should not be regarded as tubercles of the iris, and have received the name *granulomas*. Their tubercular nature has, however, been definitely settled. *Granuloma* is a term also applied to a prolapse of the iris which is covered with granulation tissue.

*Melanoma* of the iris is a dark tumor, developed from the pigment stroma of the iris, and although commonly passive and innocuous, is occasionally in another form the precursor of sarcoma.

Very rare forms of iris tumor are vascular growths (nevi), leprosy nodules, and lymphomas.

**Injuries to the Iris.—Wounds.**—An incised wound limited to the iris does not necessarily produce serious results. It will be followed by blood in the anterior chamber, which in course of time is absorbed. Wounds, however, are rarely limited to the iris, but having penetrated the ball through the cornea or ciliary region, lead to the danger of sympathetic irritation, or injure the lens and produce traumatic cataract.

In the first instance atropin, to secure physiologic rest of the iris, and a compressing bandage, will lead to a speedy cure; in the other instances the extent and position of the wound will determine the necessity for enucleation or for the treatment applicable to traumatic iritis.

**Foreign Bodies.**—A foreign body may penetrate the cornea and lodge upon the iris, or, having partially penetrated the cornea, may be pushed through it in the efforts at dislodgment and become entangled in the iris. In either event it should be removed.

An opening is made with a broad needle or narrow keratome, at the corneoscleral junction, eserin having been previously instilled, and a pair of forceps passed into the wound with which the body is seized. If this is not possible, the piece of iris upon which the substance lies may be drawn through the wound and excised. If the body is composed of steel or iron, it can be dislodged with a powerful magnet—for example, Haab's.

Certain injuries to the iris are produced by the effects of blows upon the eye, and are described under the following names:

**Iridodialysis** is a rupture of the ciliary attachment of the iris (ligamentum pectinatum). By this means an opening is produced, comparable to a false pupil; it may be detected

by the red reflex which shines through the artificial aperture, usually somewhat semilunar-shaped, situated in the periphery of the iris at the corneoscleral margin (Fig. 116). This may be quite small or involve more than half the circumference.

In a few instances reattachment of the ruptured fibers has taken place under the favoring influence of atropin, which should be vigorously instilled. Ordinarily the lesion is permanent, and, if small, occasions little trouble, although there may be diplopia. Pain, some dread of light, and hemorrhage into the anterior chamber are the immediate sequences of such an accident.

**Rupture of the sphincter** produces mydriasis and minute notchings of the pupil border. According to some authorities, the not uncommon dilatation of the pupil (*traumatic mydri-*



FIG. 116.—Iridodialysis.

*asis*) which follows a blow is always accompanied by such a lesion. The condition is not altered by treatment. Rupture of the continuity of the iris membrane by concussion is very rare (Harlan).

**Displacement of the iris** occurs under three forms: (1) *Retroflexion*, or a folding back of a portion of the iris upon the ciliary processes, usually accompanied by a partial dislocation of the lens; (2) *anteversion*, or turning upon itself of the detached portion of the iris, so that the under or uveal surface is exposed; and (3) *aniridia*, or complete detachment of the iris from its insertion, so that it lies in the anterior chamber, or even under the conjunctiva. An injury severe enough to produce this condition will usually be attended by other serious lesions of the remaining structures of the eye.

## ANOMALIES OF THE ANTERIOR CHAMBER.

**1. Alterations in its Depth.**—These are seen under a variety of conditions. Physiologically the anterior chamber is shallower in infancy and old age, and diminishes in its middle depth during the act of accommodation.

Pathologic **deepening** of the anterior chamber occurs in luxation or absence of the lens, in serous iritis and some cases of cyclitis, and is present in conical cornea and certain forms of staphyloma.

Pathologic **shallowing** of the anterior chamber occurs in chronic iritis with bulging forward of the iris, in glaucoma, and in the later stages of growths of the interior of the eye. Its depth is also lessened when there is diminution of the secretion of aqueous humor, in old cases of inflammation of the uveal tract with detachment of the retina.

**2. Alterations in its Contents.**—These may consist in mere turbidity of the aqueous, as in iritis, keratitis punctata, and glaucoma, or there may be a positive collection of pus, several times referred to under the name of *hypopyon*, and commonly seen in sloughing ulcers of the cornea and purulent inflammations of the iris and ciliary body.

Finally blood collects in the anterior chamber, a condition which receives the name *hyphema*. This follows injury to the iris, accidentally or designedly induced, and occurs in tumors of the eye, hemorrhagic glaucoma, and in severe forms of iritis and cyclitis. It is also seen in hemophilia and splenic leukocythemia (Sörger). Blood-staining of the cornea may cause a peculiar smoky hue, resembling a lens luxated into the anterior chamber.

**3. Foreign Bodies and Parasites.**—A foreign body penetrating the cornea may lodge upon the iris or fall into the anterior chamber. This may be a fragment of iron or steel or a particle of glass. Sometimes a cilium passing through a wound obtains entrance into the anterior chamber; if it remains long enough, it causes a cystic tumor (*implantation cyst*).

The two parasites described in this situation are *cysticercus* and *filaria sanguinis hominis*. In all these instances the intruder should be removed by an operation.

## CHAPTER X.

### DISEASES OF THE CILIARY BODY AND SYMPATHETIC IRRITATION AND INFLAMMATION.

**Cyclitis.**—Under the general term *cyclitis* are included various types of inflammation of the ciliary body. The close anatomic connection of the iris, choroid, and ciliary body makes diseases limited strictly to the last structure exceedingly uncommon, just as in many instances inflammations primary in the iris or choroid also involve the ciliary body.

Hence when the iris and ciliary body are associated in pathologic changes, the term *iridocyclitis* is applicable.

**Symptoms.**—The symptoms which in general lead to the diagnosis of cyclitis or iridocyclitis are the following: Edema of the lid, injection of the circumcorneal or ciliary zone, neuralgic pain, and tenderness on pressure in this region; change in the aqueous humor, which grows turbid; precipitates of exudation in grayish-brown points upon the posterior layer of the cornea, and at times hypopyon; exudation in the posterior chamber, attaching the under surface of the iris to the lens-capsule in a complete posterior synechia, the retraction thus produced causing a deepening of the anterior chamber; exudation into the vitreous causing opacities, especially in its anterior layers; and alterations in the tension of the globe, which may be increased or decreased.

The *general symptoms* of pain, photophobia, lacrimation, etc., are present in the acute types of the disease, and vision is seriously impaired according to the amount of the exudation in the pupillary space and vitreous.

**Varieties of Cyclitis.**—Systematic writers divide cyclitis into three varieties: *plastic*, *serous*, and *purulent* cyclitis.

1. *Plastic cyclitis* is characterized by severe ciliary pain

and considerable pericorneal injection. The veins of the iris are dilated, its periphery is retracted by the action of the plastic exudate in the ciliary body, so that the pupil is dilated or the anterior chamber is deepened. The tension may be high or low, according to the grade of the inflammation and the character of the secretion. If the inflammation extends, the hyperemia of the iris becomes an inflammation, the choroid is involved, and opacities form in the vitreous.

2. *Serous cyclitis* is characterized by slight pericorneal injection and is unattended by severe pain. In the beginning the pupil is dilated, the anterior chamber deepened, the aqueous somewhat turbid, and precipitates form upon the posterior layer of the cornea (see Serous Iritis and Keratitis Punctata).

There are decided diminution of vision and the rapid formation of fine opacities in the vitreous chamber in its anterior portion. Very commonly the iris is involved (serous iritis) as well as the choroid. This leads to increased tension, narrowing of the previously deepened anterior chamber, and the symptoms of glaucoma.

3. *Purulent cyclitis* is characterized by intense ciliary pain, great pericorneal injection, and edema of the conjunctiva and the upper lid. The vitreous becomes filled with large opacities, and a noteworthy feature is the formation of hypopyon, which may disappear and reappear again in a few days, its reappearance sometimes being signaled by a fresh exacerbation of intense pain. The iris and choroid commonly are included in the inflammation, the former both in a purulent and parenchymatous type, and the latter in a suppurative form.

**Pathology.**—In addition to the infiltration of the iris and exudation in the anterior chamber, there are round-cell infiltration of the ciliary bodies, much more intense in the vascular ciliary processes than in the ciliary muscle, and lines of exudation into the posterior chamber and the vitreous. The retina, choroid, and nerve are also involved in a varying degree. Later the exudates organize and contract, producing atrophy of the ciliary bodies, proliferation of pigment layers, and stretching of the processes toward the posterior pole of the lens. The exudates contain newly formed vessels, the lens

becomes cataractous, and if the inflammation has been intense, the retina is detached and *atrophy* of the entire *eyeball* results.

**Prognosis.**—Any form of cyclitis under vigorous treatment, begun early, may terminate in healing and leave a useful eye. But the prognosis is always grave, because the disease, especially in the serous form, is liable to originate glaucoma, and in the purulent form, or in the plastic variety which has become purulent, tends to produce atrophy of the iris and choroid and, as described above, *phthisis bulbi*.

Shrunken balls of this character are often tender, readily become inflamed, and may produce sympathetic inflammation in the fellow eye; this is particularly true if the original inflammation has been a cyclitis of the plastic type, which in these instances probably remains in a *chronic* state.

**Causes.**—As already stated, primary and uncomplicated disease of the ciliary body is rare. The affection usually is part of a disease-process which involves the choroid or iris, and therefore has the same etiology. According to Sydney Stephenson, inasmuch as many inflammatory affections of the iris and ciliary body are the result of constitutional ailments, which, in turn, are due to microbic infection, there exists good ground for believing the proximate cause of all cases of endogenous iridocyclitis to be the excretion by the ciliary body of micro-organisms or their products.

Injuries are common causes of cyclitis, and the inflammation may follow operations upon the globe—*e. g.*, cataract extraction. Syphilis attacks the ciliary body almost exclusively in the course of one of the forms of iritis or in connection with disease of the choroid. In a few instances gummas, strictly confined to the ciliary body, have been described. Cyclitis, the result of gout in a previous generation, has been recorded.

**Treatment.**—The principles already enunciated in connection with iritis apply to the treatment of cyclitis and need not be repeated.

**Injuries of the Ciliary Body.**—The dangers attending perforating wounds of the sclera have been described on page 332; this danger is doubly increased when the wound occurs in any portion of a zone,  $\frac{1}{4}$  of an inch wide, surrounding the



cornea, a region commonly called the "dangerous zone," after Mr. Nettleship's apt description. All the consequences of the primary infliction of the wound are present, in addition to the danger of plastic cyclitis and sympathetic inflammation.

After a penetrating wound in this region two courses are open to the surgeon—an attempt to save the eye, or immediate enucleation. If an attempt be made on the side of conservatism, the plan discussed under scleral wounds (page 333) should be employed; if not, enucleation or a substitute for this is needed. The rules for this appear on page 374.

**Tumors of the Ciliary Body.**—Round-celled sarcoma and spindle-celled sarcoma have been described in this region.



FIG. 117.—Gumma of iris and ciliary body.

According to Groenouw, the growth is usually pigmented. Sarcoma may not seriously impair the functions of the eye in its earlier stages, but as soon as the nature of the growth—which first appears as a brown mass behind the iris, rarely in the angle of the anterior chamber—is known, the globe should be enucleated. According to Groenouw, the prognosis is better than in sarcoma of the choroid. Adenomatous and primary epithelial tumor formations may be demonstrated microscopically after bleaching (Collins). Metastatic carcinoma has been recorded.

Gummas of the ciliary body have been referred to, and rarely are limited strictly to this region. Ossification of this

structure has been recorded, and myoma also occurs. Cysts and nevi have been reported.

**Iridochoroiditis** (*Cyclitis with Disease of the Vitreous and Keratitis Punctata; Chronic Serous Iridochoroiditis*).—Under the above names a disease of the eye is recognized, which, following Meyer's classification, is divided into two forms, according as the affection is primary in the iris or in the choroid.

In the first instance there are mild iritis, insignificant pain and



FIG. 118.—Microscopic section of gumma of iris and ciliary body (Fig. 117): *l*, Remains of lens; *c. p.*, atrophied ciliary processes; *g*, gummatous growth involving base of iris and ciliary body, containing in its center a cyst, *c*.

ciliary congestion, deepening of the anterior chamber, and spots in the posterior layer of the cornea, as in serous iritis and keratitis punctata. The chronic inflammation continues, relapses take place, exudation occurs behind the iris, while its pupillary margin is bound down so that the surface is irregularly or entirely bulged forward, and, if the pupil is not too much occluded, the ophthalmoscope will reveal flocculi in the vitreous. The tension may now become raised and the eye pass into secondary glaucoma.

In the other type the process passes from behind forward,

beginning with patches of choroiditis, which increase in extent and depth, the nutrition of the vitreous is impaired, and opacities form, the lens is altered and pushed forward, the iris becomes embodied in a plastic inflammation, with narrowing of the anterior chamber and marked loss of vision. As the disease of the uveal tract continues the lens becomes opaque, the eyeball softens, the retina may be detached, and finally shrinking or phthisis occurs.

This disease is chronic in course, and the symptoms, especially those confined to the iris, are insidious. A cure may be obtained in the earlier stages, but the danger is the production of glaucoma through rise of tension, or atrophy and shrinking of the ball from extension of the morbid process.

The affection usually occurs in young adults, and commonly is symmetric. It has been attributed to inherited gout, to rheumatism, and to syphilis. It also occurs from prolonged work associated with loss of sleep, from defective nutrition, and, in women, apparently is due to menstrual irregularities. Certain cases have been attributed to diseases of the nasopharynx, especially atrophic rhinitis (Senn and Spigg). In other instances no assignable cause is present, or the disease has started as the result of synechiæ from a former iritis.

**Treatment.**—In the earlier stages atropin, provided there is no rise of tension, should be employed; in the event of increased tension without synechiæ, pilocarpin or eserine may be tried.

Internally, mercury by inunction is indicated if the patient is robust, but in the form of the bichlorid combined with iron, if there is anemia. Iodid of potassium may also be tried. Pilocarpin diaphoresis is of service. Subconjunctival salt injections may be tried.

When the presence of firm posterior synechiæ has blocked the communication between the anterior and posterior chamber, this should be reopened by a good peripheral iridectomy, which, if the lens is opaque, may be combined with its extraction. Even in eyes in which softening has begun, provided the field of vision still remains intact, good results will sometimes follow a successful iridectomy.

**SYMPATHETIC IRRITATION AND SYMPATHETIC INFLAMMATION OR OPHTHALMITIS.**

These terms are applied to affections in which one eye is implicated as the result of disease or injury to the other, and represent *two essentially different conditions*.

It is customary to describe the eye which is implicated as the result of the disease or injury of its fellow as the *sympathizing* eye, and the one affected by the disease or injury which causes the implication the *exciting* eye.

**Conditions Producing Sympathetic Affections.**—According to Alt<sup>1</sup>, the entire nervous apparatus of the diseased eye participates in the transmission of the affection to the other. Generally one or other of the following conditions is present:

(1) Wounds of the ciliary region which set up a traumatic iridocyclitis or uveitis. The ciliary region is the zone previously described by the term borrowed from Mr. Nettleship, "dangerous zone." Traumatism probably caused over 80 per cent. of the cases of sympathetic inflammation. (2) Foreign bodies in the eye. (3) Perforating wounds or ulcers of the cornea in which the iris has become incarcerated, or scars involving the ciliary body. (4) Operations upon the eye—extraction of cataract, sclerotomy, iridodesis, iridectomy, discission, and reclination. (5) Luxation, wounds, and calcification of the lens. (6) Intra-ocular tumors when associated with iridocyclitis (Schirmer). (7) Ossification and calcification of the choroid and ciliary body. (8) Pressure of an artificial eye or incarceration of the stump of the optic nerve in scar tissue, after the operation of enucleation.

According to O. Schirmer, there is no sound evidence that herpes zoster ophthalmicus, symblepharon, intra-ocular cysticercus, subconjunctival rupture of the globe (without associated iridocyclitis), or spontaneous inflammation of one eye can cause sympathetic ophthalmitis, although sympathetic

<sup>1</sup> It is stated that eyes which are, or have been, the subjects of purulent panophthalmitis do not produce sympathetic ophthalmitis. Alt, however, in his analysis of more than 100 cases, found 13 eyes enucleated for sympathetic iridochoroiditis, the other having been lost by purulent panophthalmitis.

irritation may, no doubt, arise in consequence of any of these conditions.

**Sympathetic irritation** (*sympathetic neurosis*) is a functional disturbance which presents a series of symptoms, comprising photophobia, lacrimation, blepharospasm, defective or impaired accommodation, lessened visual acuity, inability to perform close work, neuralgic pain through the distribution of the supra-orbital nerve, photopsia, contraction of the field of vision, and hyperemia of the eye-ground.

With this there may be some tenderness on pressure over the ciliary region. Hence when observing an eye so affected that it is likely to produce either sympathetic irritation or sympathetic inflammation it is most important to watch for tenderness in the ciliary region, to measure the amplitude of accommodation, and to examine the field of vision. The tendency of this condition, which is looked upon as a neurosis, is to recur. It disappears entirely with the removal of the exciting eye or of the exciting cause.

**Symptoms in the Eye Exciting Sympathetic Irritation.—**

An eye so injured or diseased that it is liable to produce the condition described in the preceding paragraph is apt to show, during the course of the irritation, attacks of congestion in the ciliary region, photophobia, tenderness on pressure, lacrimation, and neuralgic pain. These may subside, just as the sympathetic irritation in the fellow eye may subside, and recur again and again. Sympathetic irritation may also be induced by minor lesions—for example, retained foreign bodies in the conjunctival cul-de-sac.

**Sympathetic inflammation** (*sympathetic ophthalmitis*) occurs in several forms, sometimes arising in the wake of an attack of irritation, sometimes coexisting with it, but frequently without any premonition or association of this character. None the less, if patients have had sympathetic irritation, it is proper to warn them that this may pass on to irremediable structural changes. On the authority of Mr. Gunn it is stated by Nettleship that marked oscillation of the iris often occurs when a sympathetic irritation is about to give place to an inflammation.

With or without warning, sympathetic ophthalmitis, or, as it should be called, *sympathetic uveitis*, because the uveal tract is especially involved, presents itself:

1. As an *iridocyclitis*, plastic or malignant—*i. e.*, an inflammation characterized by pain, photophobia, pericorneal congestion, discoloration of the iris, closure of the pupil by exudation around its margin and behind the iris, tenderness over the ciliary region, narrowing of the anterior chamber, effusion into the vitreous, opacity of the lens, detachment of the retina, and finally shrinking of the eyeball.

2. As a *serous iritis*, more accurately a *serous iridocyclitis* (Panas) or *serous iridochoroiditis* (de Wecker), causing turbidity of the aqueous, deepening of the anterior chamber, punctate opacities on the posterior layer of the cornea, rise in tension, slight ciliary injection, opacity in the anterior layers of the vitreous, and some involvement of the ciliary body and choroid. This may pass into a *malignant iridocyclitis*. Not infrequently, if not in all the cases, there is a *papilloretinitis* coexisting with the uveitis; in some cases sympathetic papilloretinitis is the primary affection.

3. As a *choroidoretinitis* in which the outlines of the papilla are hazy, the retina edematous, the retinal veins dilated and tortuous, with or without the appearances of slight serous iritis. This is a rare manifestation.

These symptoms in the sympathizing eye may be either *acute* or *chronic*. Often they come on insidiously and are not discovered by the patient until serious damage has been done. A premonitory symptom of great importance, and one which should always be searched for in cases in which sympathetic irritation or inflammation is likely to take place, is an almost characteristic tenderness in the ciliary region, frequently in a circumscribed spot, which may be picked out with the end of a probe. When this is pressed upon, the patient shrinks from the touch in a peculiar and striking manner. Sometimes an exactly similar tender spot is found in the ciliary region of the exciting eye. Biehler and von Hippel have demonstrated that fluorescein will color the endothelium of the cornea in certain uveitic inflammations when the superficial layers of the cornea

are still intact and when ordinary examination fails to reveal these early changes. Alberti suggests the use of this test in cases of suspected, but not yet manifest, sympathetic inflammation.

**Symptoms in the Eye Exciting Sympathetic Ophthalmitis.**—Preceding the development of any of the types of sympathetic ophthalmitis, the exciting eye usually presents obvious iritis or iridocyclitis, congestion, and alteration in the tension; but the local manifestations in the exciting eye may not be characterized by pain, and consequently may escape attention, and although necessarily the vision is disturbed, the eye need not be a blind one. Indeed, there are no phenomena in the exciting eye which may be designated as characteristic. Schweigger is unwilling to recognize a clinical picture peculiar to the sympathizing eye.

**The Period of Incubation.**—The period of incubation, or that period of time between the reception of the injury or disease in the exciting eye and the development of *inflammation* in the sympathizing eye, varies considerably, in the majority of cases being from three to six weeks. Exceptionally the disease begins as early as the fourteenth day and has been postponed as late as twenty years, in Alt's collection one case being stated to have occurred as late as sixty years after the exciting disease. The maximum interval is, however, difficult to state with accuracy.

Sympathetic irritation may arise within a very few days after the reception of an injury. It has occurred within the first forty-eight hours.

**Pathogenesis of Sympathetic Ophthalmitis.**—Formerly it was almost universally thought that this disease was due to a reflex action through the ciliary nerves, and on this theory the name "sympathetic" was applied. The exact nature of this grave malady is not perfectly known, nor is the path of the morbid changes which precede the inflammation fully mapped out, although the older hypotheses have largely been abandoned for the *theory of infection*.

According to Deutschmann, the inflammation is a progressive process in the continuity of the tissue of one eye to the other

by way of the optic nerve apparatus, and is of bacterial origin ; hence a *migratory ophthalmitis*. Deutschmann's researches have, however, not always been confirmed (Gifford, Mazza, Randolph, Limbourg, Levy, and Greeff), and "the migration theory is still a hypothesis, just as is the ciliary nerve theory" (Greeff). The latter theory, in a modified form—*i. e.*, that disturbances of nutrition and in the circulation, caused by irritation of the ciliary nerves in the "exciter," create the inflammation in the "sympathizer," is maintained by Schmidt-Rimpler. Bellarminoff and Selenkowsky believe that all cases of sympathetic disease may be explained by the action of a toxin which is produced by the bacteria which have entered the primarily affected eye, and which reach the other eye by means of the lymph and diffusion streams. Even those who have failed to confirm Deutschmann's conclusions are unwilling to deny the parasitic origin of the disease, but believe that neither the micro-organism (perhaps its metabolic products) nor the route of transmission has been discovered. Certainly in man the ordinary pus-organisms have not been proved to produce the disease.

**Treatment.**—The most important consideration is *prophylaxis*, or, in other words, the management of the eye originally affected. This depends upon the character and situation of the wound or upon the stage of the disease, and upon the amount of vision possessed by the injured or diseased organ.

In the section devoted to treatment of wounds of the sclera (page 333) the method was pointed out by which eyes seriously wounded might be saved. Schirmer believes that the treatment of injured eyes should include full doses of mercury.

It may sometimes happen, especially in private practice, when every advantage of nursing and careful watching is at hand, that eyes may be saved which would be sacrificed in the working-classes. The attempt requires the gravest thought before it is undertaken, because the onset of a sympathetic ophthalmitis may be insidious, and when once begun treatment rarely fully removes the structural changes which have taken place. The propriety of operating must be determined by regarding the following rules, which are modified from



those given by Schirmer and Swanzy, and represent the published experiences of the best authorities.

Enucleation, or one of its substitutes, should be performed on—

1. An eye with a wound so situated as to involve the ciliary region, and so extensive as to destroy sight immediately, or to make its ultimate destruction by inflammation of the iris and ciliary body reasonably certain.

2. An eye with a wound in this region already complicated by severe inflammation of the iris or ciliary body, even if sight is not destroyed; or an eye containing a foreign body which judicious efforts have failed to extract, and in which severe iritis is present, even if sight is not destroyed.

3. An eye the vision of which has been destroyed by plastic iridocyclitis, or one which has atrophied or shrunk, provided there are tenderness on pressure in the ciliary region and attacks of recurring irritation; or without waiting for signs of irritation.

4. An eye the sight of which has been destroyed, even though sympathetic inflammation has begun in the sympathizing eye, in the hope of removing a source of irritation, and thus rendering treatment to the second eye more effectual.<sup>1</sup>

5. An eye in which the wound has involved the cornea, iris, or ciliary region, either with or without injury to the lens, and in which persistent sympathetic irritation in the fellow eye has occurred, or in which there have been repeated relapses of sympathetic irritation.

6. An eye either primarily lost by injury or in a state of atrophy, associated with signs of sympathetic irritation in the fellow eye.

It is universally conceded that the enucleation of an eye (*preventive enucleation*) primarily injured, the visual function of which cannot be restored, is the surest way of preventing sympathetic ophthalmitis. It is to be remembered, however, that even a very early enucleation does not necessarily prevent sympathy in the fellow eye, because the infective process may

<sup>1</sup> This rule is not adhered to by some surgeons, because it is believed by them that no good results will follow, but there is no proof that the practice is harmful.

have begun before the operation, and may not develop for several weeks. It has occurred fifty-three days after the enucleation of an eye injured twenty days prior to its removal (Stephenson). In place of enucleation, evisceration has been practised, but this operation has been followed by sympathetic inflammation. Resection of the optic nerve (neurectomy) does not provide absolute security, but if the patient declines enucleation it may be used as a substitute.

If sympathetic inflammation has begun, the rules just quoted are not applicable, and enucleation must not be performed if there is any vision in the exciting eye, which in the end may prove to be the more useful organ. The same principles of treatment already enunciated in regard to iritis and iridocyclitis are applicable.

In the treatment of the sympathetically affected eye, operation usually has no place. Both iridectomy and sclerotomy have been advised, but it is better to await the subsidence of acute symptoms before attempting any surgical interference unless the intra-ocular tension be inordinately raised, and then scleral incision may be practised.

The *general treatment* consists in confinement in a darkened room (moderate exercise with eyes well protected is permissible in subjects failing for lack of it); complete functional rest of the eyes and atropin locally, provided there is no rise of tension and no atropin irritation; and leeches to the temple, if the inflammation is florid. Mercurial inunctions are important, and free diaphoresis, either with pilocarpin or by vapor baths, has been advised; in debilitated cases a course of tonics and alteratives is advisable; under any circumstances full doses of quinin should be exhibited. Intra-ocular injections of bichlorid of mercury should not be employed. Subconjunctival injections have been recommended. The author's experience with them in this disease has not been encouraging.

Under such treatment the affected eye will recover with useful sight, pass into atrophy or phthisis bulbi, or grow quiet, with the formation of complete annular adhesions of the iris to the capsule of the lens, which has become cataractous.

To improve vision under the last-named condition, iridec-

tomy and iridotomy have been tried, but the results are usually unfavorable. Extraction of the cataractous lens, with iridectomy, also presents serious difficulties. For those cases in which a transformation of the iris, lens, and capsule into a tough, opaque, and inelastic tissue has occurred, Mr. George Critchett practised the following operation: The patient is placed under the influence of an anesthetic, a speculum is introduced, the globe is fixed, and a fine cutting needle is introduced through the cornea, its point being directed to the center of the capsule. This structure is penetrated by making a rapid rotary movement, on the principle of a gimlet. A second needle is introduced from the opposite side and the points separated from each other, the result being a rent in the center of the capsule and the escape of the soft lens matter. The operation must be repeated at proper intervals until a clear pupil has been obtained. It is suited to young eyes, although it may succeed in adults, as in one case in the author's practice. Care should be taken to avoid wounding the iris. The same operation is advised by Mr. Story.

**Prognosis.**—The prognosis of sympathetic ophthalmitis is essentially grave, although Alberti's statistics indicate that it is not so bad as in former times, probably owing to modern antiseptic methods, and also that its manifestations are not so malignant. Complete and permanent recovery may sometimes occur. Cases in which neuroretinitis is present, which, according to Schirmer, never begins after removal of the exciting eye, are cured by enucleation, not immediately, like sympathetic irritation, but in the course of several days.

More frequently, especially in the forms which appear as an iridocyclitis or iridochoroiditis, the sight of the eye is lost and the organ shrinks. The varieties which appear as a serous iritis give the greatest hope for a good result. It is extremely important to warn patients of the grave nature of this malady, and if an attempt is made to save an eye injured in the way already described, it must be done with the full understanding of the serious risks which are undertaken, and the patient kept under constant observation.

## CHAPTER XI.

### DISEASES OF THE CHOROID.

**Congenital Anomalies.**—Two striking congenital anomalies occur in connection with the choroid :

1. *Coloboma of the choroid* is a large defect in the choroid, almost always in its lower part, and often associated with a similar vice of conformation in the iris.

Examined with the ophthalmoscope the deficient area appears as a glistening, pearl-colored patch, often irregular on its surface, owing to the development of several protrusions and corresponding intervening depressions, and bordered by an irregular pigment line. The retina may be recognized as a translucent veil covering the defect, and the retinal vessels occasionally pass into the depressions. The coloboma may include the optic nerve entrance, either partially or completely, or may be separated from it by a bridge of healthy choroid. It may be confined to the area around the disc, or pass downward as far as it can be followed, and be connected with a similar defect in the iris from which it is separated by a band of choroid tissue. Coloboma of the choroid is seen also without coloboma of the iris. Sometimes several defects are present on the same eye-ground. Imperfect closure of the fetal cleft (choroidal fissure) explains some cases; others have arisen from intra-uterine inflammation.

In addition to coloboma in the usual situations, similar defects have been described in the macular region (*macular coloboma*, Fig. 124) and the nasal half of the eye-ground (B. A. Randall and the author), and for these defects, which do not involve the optic disc, Lindsay Johnson has proposed the name *extra-papillary coloboma*. Macular colobomas have been explained on the theory of intra-uterine choroiditis, but Johnson thinks they present many points in common with cutaneous nevi, and may be looked upon as the atrophied remains of nevoid growths in the choroid.

2. *Albinism*, or a congenital want of pigment in the choroid

and iris, is a deformity met with both in a *complete* and *incomplete* form.

The iris has a pink or pink and yellow appearance, due to the reflection of light from its own blood-vessels and from those of the choroid, which, in the most pronounced forms of the defect, can be seen with the ophthalmoscope down to their finer branches. The anomaly is most marked in early



FIG. 119.—Congenital defects in the choroid; one large coloboma in the usual situation with two smaller areas between it and the disc.

childhood, is almost invariably associated with lack of pigmentation in the hair, and is accompanied by nystagmus, amblyopia, and high grades of refractive defects. In many instances albinism has been observed in several members of the same family, and seems to be hereditary. The influence of heredity is denied by Gould.

**Hyperemia of the Choroid.**—It is extremely doubtful whether an ophthalmoscopic examination can demonstrate hyperemia of the choroid, just as later we shall see that such a condition of the retina is difficult to determine. An actual

hyperemia could fairly be shown to exist, only by finding a real distention of the vessels of the choroid, which usually are invisible, and the *congestion of the choroid*, described with myopic or asthenopic eyes, and as the result of exposure to bright light and heat, is more often a figure of speech than a proved pathologic condition. The student should be on his guard not to mistake an exposure of the choroidal vessels by absorption of the pigment epithelium for a condition of hyperemia.

Nevertheless, in eyes subjected to prolonged strain, the result of uncorrected ametropia, certain changes in the normal appearance of the fundus arise, which are usually described under the vague term "choroidal disturbance." We may assume hyperemia when the nerve-head presents distinct redness, which is imperfectly differentiated from the unduly flannel-red appearance of the surrounding choroid, or when the choroid, instead of exhibiting its usual uniform red color, has changed into what has been denominated a "woolly choroid," with faint dark areas in the periphery, indicating the interspaces between the choroidal vessels, and more or less pronounced retinal striation surrounds the disc. This is a familiar picture in many cases of "eye-strain." A similar appearance may follow exposure to great heat and light, and may be seen in the eyes of puddlers, etc.

**Treatment.**—In this condition, often associated with the subjective symptoms of aching eyes, some intolerance of artificial light and distinct asthenopia, the eye should be atropinized, dark glasses should be worn, and when the irritable condition of the fundus has sufficiently subsided, a proper correction of the refractive error should be ordered.

As an adjuvant to the local use of the atropin, the internal exhibition of small doses of iodid of sodium, bromid of potassium, and fluid extract of ergot serve a useful purpose.

**Choroiditis.**—Under the general term *choroiditis* are included various types of inflammation of the choroid which may be—(a) idiopathic; (b) part of the symptomatology of disorders in other portions of the uveal tract, or indicative of general disease; and (c) traumatic.

**Symptoms.**—Certain symptoms, for the most part revealed only by the ophthalmoscope, are present :

1. Alteration in the uniform dull-red surface of the eye-ground caused by (a) the absorption of the pigment epithelium ; (b) patches of pale-yellow color with ill-defined boundaries due to exudate (*recent choroiditis*) ; (c) patches of white color due to exposure of the underlying sclerotic (*atrophic choroiditis*) ; and (d) patches of black pigment, variously shaped, scattered over the fundus, and usually bounding the spots of atrophy (*pigment heaping*).

2. Absence of external manifestations indicative of the deep-seated disease, except when acute and purulent forms, in which the diseased process is not localized in the choroid, are accompanied by injection, chemosis of the conjunctiva, etc.

3. Changes in the transparent media (lens, vitreous) by the formation of opacities, as a secondary result of the choroidal disease.

*Subjective symptoms* peculiar to choroiditis do not exist.

Pain usually is not present except in purulent forms, and in such varieties as may be complicated with iritis.

Disturbance of vision is in direct relation to the situation of the lesions and the amount of atrophy. If the choroidal disease is peripheral, visual acuity may be unaffected ; if atrophic patches occupy the macular region, sight may be greatly diminished or practically obliterated. It is remarkable, however, that even in extensive diffuse choroiditis good vision may still be present. If the disease has caused secondary changes in the vitreous or lens, these add to the depreciation of visual acuity.

Scotomas, both positive and negative, may be present. Contraction of the field of vision is found in certain types of choroiditis, and especially if secondary atrophy of the optic nerve has occurred.

**Diagnosis.**—This is readily made by observing with the ophthalmoscope the appearances briefly summarized in paragraph 1 of the general symptoms.

Inasmuch as choroiditis, in the large majority of cases, is complicated with secondary retinitis, it is difficult to decide

whether the pigment lies in the choroid or retina. If the pigment mass is covered by a retinal vessel, and at the same time is situated in a deeper layer than this, its position is judged to be in the choroid; if the retinal vessel is covered by the pigment mass, and the latter is situated more anteriorly, its position is assumed to be in the inner surface of the retina, to which spot it has wandered through secondary involvement of the retina. Pigment characterized by a "lace-like pattern," or resembling bone-corpuscles, is always in the retina (Nettleship). A commingling of these positions in the same eye-ground is common.

**Course, Complications, and Prognosis.**—A choroiditis may be sudden in onset and pursue an acute course; for example, an acute choroiditis at the posterior pole of the eye resulting in a permanent myopia or in the purulent forms of the disease.

More commonly the course of choroiditis is slow and chronic. Beginning with exudation or hemorrhage, it passes by slow stages through the period of absorption, atrophy, and pigment accumulation. It is by the last signs that a former choroiditis is recognized, and the changes are called "old choroiditis," or "choroidoretinitis."

The following structures are liable to become involved during the course of a choroiditis: The retina, which from its intimate association with the choroid through the pigment epithelium probably does not escape in any instance, and in many the association of disease is so close that we apply the term *choroidoretinitis* or *retinochoroiditis*; the optic nerve (*choroiditic atrophy*); the vitreous (*vitreous opacities*); the crystalline lens (*posterior polar cataract*); the iris (*iridochoroiditis*); and the sclerotic (*scleroticchoroiditis*).

The *prognosis* in choroiditis is always grave, and although careful treatment may preserve sight, in many instances great loss of vision and entire blindness may ensue. Necessarily the prognosis as to vision depends upon the position of the disease and its relation to the macula.

**Pathologic Anatomy.**—In non-purulent forms of choroiditis collections of round cells are gathered in the choroid, espe-



cially along the vessels between this membrane and the retina, and hemorrhagic extravasations may be seen. Organization of this round-cell exudate causes atrophy of corresponding portions of both choroid and retina, union of the two membranes, disappearance of the pigment layer of the retina, except at the edges of the lesions, where it is proliferated, and wandering of the pigment cells into the retina along the lines of the vessels. In purulent choroiditis there is a dense cellular infiltration of the choroid, rapid involvement of retina and vitreous, panophthalmitis, and subsequent phthisis bulbi.

As already stated, choroiditis may be acute or chronic, and, like iritis, has been divided, according to its pathologic nature, into *plastic*, *serous*, and *purulent* forms. In like manner, when the cause of choroiditis is definitely known, it is customary to indicate this in the terminology—*i. g.*, syphilitic choroiditis.

For the present purpose choroiditis may be divided into *superficial* and *deep* choroiditis, and a well-recognized classification may be adopted, which places all forms under one of two heads: (1) *Non-suppurative exudative choroiditis* and (2) *suppurative choroiditis* and *iridochoroiditis*.

**Treatment.**—This in general terms demands perfect rest for the affected eye, blood-letting from the temple in the early stages, protection from glaring light, and the administration of alteratives, the iodids and mercurials, especially if there is any reason to suspect syphilis. Further details will be reserved for the sections devoted to the several varieties of choroiditis.

**Superficial Choroiditis** (*Epithelial Choroiditis*).—Instead of the general dull-red appearance of the eye-ground, the larger vessels may be manifest as rather broad, reddish, or yellowish-red stripes, which traverse the fundus in an interlacing manner, and between which are the dark intervascular spaces, many of them having a lozenge-shaped appearance. This is due to the absorption of the pigment epithelium and the capillary layer which lies just beneath it.

In certain instances it is physiologic, and is commonly seen in the periphery of eye-grounds, often by preference occupying a space down and in from the disc.

It may be universal, the only portion of the eye-ground escaping being the region directly confined to the macula, and it then presents a striking picture to the ophthalmoscope. The larger vessels of the choroid-stroma pass in a sinuous manner across the eye-ground, bringing out into distinct relief the pigmented connective-tissue cells of the choroid proper, which lie between them (consult Fig. 125, page 390). The atrophy is superficial, and of itself does not disturb vision. Such appearances are seen in myopia; in "stretching eyes," when hyperopic refraction is diminishing or passing into myopic refraction; in glaucoma; and sometimes are associated with retinal conditions—for example, pigmentary degeneration.

**Treatment.**—An eye thus affected should be put at rest, its refractive error corrected after the use of atropin or similar mydriatic, and the patient be given an alterative. If this is an associated symptom in a glaucomatous eye, or one with pigmentary retinitis, the present directions do not apply.

**Deep Choroiditis.**—**1. Diffuse Exudative Choroiditis.**—Instead of the normal red of the eye-ground the ophthalmoscope reveals white or yellowish-white plaques, sometimes separated by partly normal choroid, more often running into one another until a huge expanse of exposed sclera is seen throughout the fundus.

The white patches appear speckled because numerous pigment masses of black color are collected upon them, irregular in form, sometimes gathered in lumps, sometimes assuming variously shaped groups. They lie beneath the retinal vessels for the most part, although usually pigment will be found collected upon these retinal vessels showing the participation of the retina in the process (*choroidoretinitis*) (Fig. 120). In other patches the atrophy has not been sufficient to expose the glistening white sclera, and here will be found the appearances described in superficial choroiditis, namely, band-like, orange-yellow, or light red vessels, freely anastomosing with each other, and, between them, the pigmented epithelium. In still other spots it may be that a yellowish exudate is evident, which is the earlier stage of what afterward becomes an area of absorption, surrounded and partly covered by black pig-

ment heaping. In cases like this all the stages from yellowish extravasation to complete atrophy are visible.

**2. Disseminated Choroiditis.**—Another form, which may be looked upon, according to a classification adopted by some authors, as the circumscribed variety of the type just described, is that which is known as *disseminated choroiditis*.

In this type, usually beginning in the periphery, but gradually approaching the center of the eye-ground, numerous round or oval spots surrounded by black margins are found. The white center of the spot is the exposed sclera; the black margin, the altered pigment. Again, instead of a white cen-

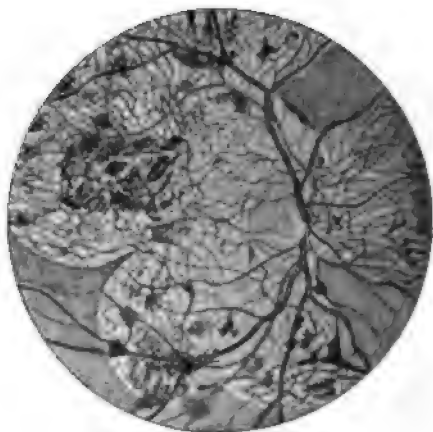


FIG. 120.—Diffuse exudative choroiditis with choroidoretinitis (E. von Jaeger).

ter there may be a single black mass, in its turn encircled by a yellowish ring. A very characteristic appearance arises when the spots assume a punched-out look, as if a sharp instrument had cut out the tissue down to the sclera, the margins of the incision being bordered with pigment.

These spots of disseminated choroiditis vary greatly in number. There may be only one or two, or the eye-ground may be dotted over with them. Between the spots the choroidal tissue is comparatively healthy. Like the diffuse variety, the earlier stages of such spots consist in small, yellowish exudations, which gradually absorb, producing the atrophic marks which have just been described. The relation of the retinal

vessels to the pigment epithelium is the same as in the previous variety (Fig. 121).

Vitreous opacities are often present, either faint and floating, or large, string-like, and membranous. There may also be cataract at the posterior pole of the lens.

The optic nerve becomes affected in the later stages of this disease and undergoes a species of atrophy to which the name *choroiditic atrophy* has been applied. The edges of the disc are slightly hazy, the color a reddish-yellow, and there is contraction of the retinal vessels.

**Causes.**—The cause of deep choroiditis, either diffuse or circumscribed, is acquired syphilis in a great number of

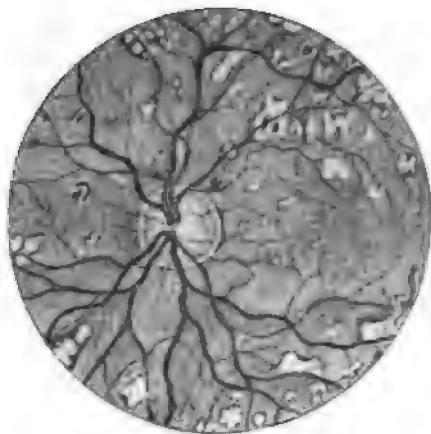


FIG. 121.—Disseminated choroiditis (de Wecker).

cases, and appears from six months to two years after the initial infection. Sometimes it is postponed to a much later period (tertiary period). Opacities in the vitreous increase the probability of syphilis, and although certain types have been looked upon as especially characteristic of this disease, it is not safe to attempt to make a diagnosis of syphilis simply by the appearances of any of the varieties of choroiditis. Disseminated choroiditis, choroidoretinitis, and secondary pigment degeneration of the retina are seen in children the subjects of hereditary syphilis. Choroiditis due to acquired syphilis usually affects both eyes.

A disseminated choroiditis (*hereditary choroiditis*) affecting both eyes is occasionally encountered as a family disease independently of syphilis, and associated with the disorders of the central nervous system (Hutchinson).

A choroiditis quite indistinguishable from the forms described may result from an injury. Patches of choroiditis are found in the eyes of children born with cataract. Choroiditis is also due to disturbances of nutrition, tuberculosis, anemia, chlorosis, and scrofula, and sometimes no cause can be found.

**Prognosis.**—The prognosis is always a grave one; it is best in the syphilitic cases.

**Treatment.**—This depends upon the cause. If it is syphilis and the patient is robust, inunctions of mercurial ointment should be prescribed, to be followed by iodid of potassium. Later, a prolonged course of the bichlorid of mercury with the tincture of iron is advisable. Subconjunctival injections of bichlorid of mercury have been recommended; similar injections of salt solution are regarded by some authors as useful therapeutic measures; the author has not been favorably impressed with these remedies under these circumstances, although there can be no objection to the trial of the saline solutions. Anemia and scrofula require the usual treatment. Pilocarpin sweats may be tried, and in non-syphilitic cases their effect is sometimes strikingly favorable; in old cases strychnin and the galvanic current have been advised. All close work must be forbidden; the eyes should be protected with dark glasses.

**Central choroiditis** is the name applied to choroiditis confined to the region of the macula.

There may be an irregular patch of exudation, semi- or completely atrophic, and bounded by pigment. This is recognized objectively by the ophthalmoscope, and subjectively by a scotoma in the field of vision marking this region. Sometimes the lesions consist of areas of yellowish exudate, interspersed with small round and linear pigment masses and dot-like hemorrhages.

Again, the macula may be occupied or surrounded by a

large white patch, the rest of the eye-ground being normal. This type is sometimes known as *senile areolar atrophy of the choroid*. The area may be entirely circular and the deep vessels exposed, or they may be atrophied and converted into white lines (*sclerosis of the choroidal vessels*).

In the same region there is observed another variety of the disease, first described by Tay and Hutchinson as *central senile guttate choroiditis*, marked by the appearance of numerous, white, glistening dots, somewhat resembling the earlier



FIG. 122.—Central atrophic choroiditis; on the temporal side of the disc there is a semiatrophic area—the so-called conus (from a patient in the Philadelphia Hospital).

stages of albuminuric retinitis (Nettleship) and always symmetric, though sometimes an interval of time elapses before the implication of the second eye. The white spots are due to colloid degeneration and calcareous formations in the choroid, and are associated with secondary involvement of the retina. Usually there are contraction of the field of vision and negative scotoma. Large areas of *colloid change* may also occur without disturbance of vision (*verrucosities of the choroid*, Fig. 123).

It is important, if possible, to recognize all forms of central choroiditis before a cataract operation is performed. This may be suspected if there is imperfect central fixation for light, but really can be positively determined only when the cataract is still incipient and the ophthalmoscopic examination is possible.

**Causes.**—Central choroiditis of inflammatory type may be caused by syphilis and also by blows upon the eye. Chronic atrophic choroiditis in this region is seen in myopia, and Gould has described macular choroiditis as the result of uncorrected ametropia and insufficiency of the internal recti muscles, even

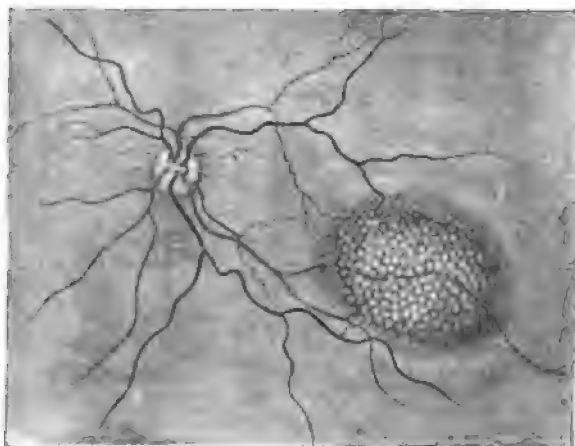


FIG. 123.—Colloid change in the macular region.

in non-stretching eyes ("*ametropic choroiditis*"). Senile changes account for senile central choroiditis and the guttate variety.

**Treatment.**—In the syphilitic variety the usual remedies are indicated. In types connected with refractive error, the best possible correction should be given and absolute eye-rest enjoined. In the senile varieties, both the ordinary and the guttate types, treatment appears to have no influence.

**Unclassified Forms of Choroiditis.**—Besides the diseases of the choroid which have been described, others appear which cannot be definitely classified:

Large patches of atrophy not located in special portions of the choroid, resulting probably from the absorption of former

hemorrhages, or, perhaps, tuberculous areas; *hemorrhagic choroiditis* occurring, as pointed out by Hutchinson, especially in young men, and resulting in numerous spots of atrophy which are not readily distinguished from those of the syphilitic variety; yellowish or other spots of choroidal disease, which have been attributed to the action of intense light or the glare of heat; slight macular changes in the form of small yellowish or maroon-colored spots, sometimes with a few scattered pigment granules in the immediate vicinity of the fovea, which do not affect vision and are unnoted by the patient. These have been attributed by some authors to the

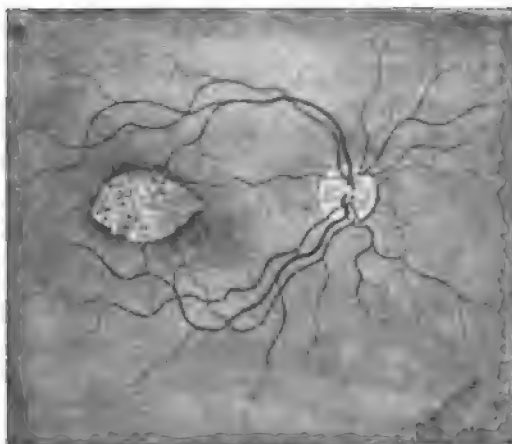


FIG. 124.—Macular coloboma (compare with Fig. 122).

influence of abnormal refraction, but are sometimes seen in association with transient albuminuria, and probably represent small spots of degeneration, inclosed by a single capillary loop which has become impervious.

**Myopic Choroiditis.**—Atrophy of the choroid, commonly of a local character, occurs in severe, or, as it has sometimes been called, malignant myopia, and is observed either in connection with, or surrounding, the nerve-head. It is caused by the elongation which occurs at the posterior pole of the eye, and receives the name *posterior staphyloma*.

The term *scleroticchoroiditis posterior* is also applied to this



variety of choroidal change, just as anterior sclerotic choroiditis is the name given to the inflammatory affection which attacks circumscribed portions of the anterior part of the choroid, with corresponding portions of the sclerotic, and which, in aggravated instances, may give rise to staphylomatous bulging and gradual loss of vision by opacity of the vitreous and cornea (see page 331).

*Semiatrophic* and *atrophic crescents* (often inaccurately called "conus") also appear at the outer margin of the disc in astigmatic eyes, and in eyes undergoing change owing to the dis-

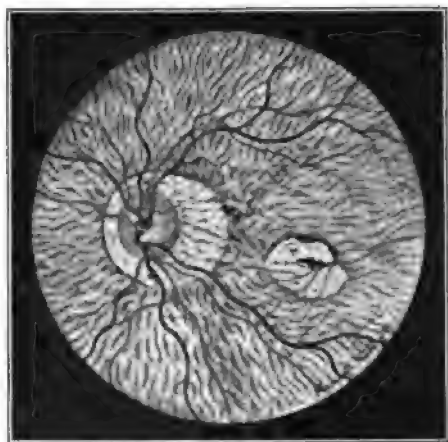


FIG. 125.—Myopic choroiditis. The cut illustrates posterior staphyloma—the white area surrounding the nerve: atrophic choroiditis in the macula—the white patch bordered by pigment in the central part; and general exposure of the choroidal vessels by absorption of the retinal pigment epithelium.

tention of their coats from too close work, aggravated by imperfectly or improperly corrected errors of refraction.

In the macular region in myopia there may be very decided semiatrophic or atrophic patches having the general characteristics of the spots already described, and greatly interfering with vision. The process begins in the form of small rents which gradually coalesce into an atrophic patch. In like manner this area may be involved by a hemorrhage in progressive myopia, which after absorption leaves impaired vision, owing to the damage to the overlying retina. The vessels of the

## Suppurative Choroiditis and Iridochoroiditis 391

choroid are exposed by maceration and absorption of the retinal pigment epithelium, causing the appearance described under superficial choroiditis (Fig. 125).

**Suppurative Choroiditis and Iridochoroiditis.**—Acute iritis occasionally becomes complicated with inflammation of the choroid (page 345), and a chronic type of iridochoroiditis, which tends to loss of vision and shrinking of the eyeball, has been described (pages 356 and 367).

The present disease, however, is distinguished by a suppurative process between the retina and choroid, which extends into the vitreous, and spreads into the entire uveal tract.

**Symptoms.**—There are edema of the lids, chemosis of the conjunctiva, haziness of the cornea, inflammation of the iris and ciliary body, and, it may be, hypopyon. If there is sufficient transparency of the media, a mass of exudation may be seen behind the lens in the vitreous, giving rise to a yellowish reflection, when viewed by transmitted light (*pseudoglioma, destructive ophthalmitis*, see also page 454). At first the tension may be raised and the anterior chamber is shallow; later the tension is lowered.

In addition to these objective symptoms there are severe brow-pain, tenderness of the globe, loss of vision, and constitutional symptoms, as chill and fever.

The ultimate result depends upon whether the disease remains localized in the uveal tract and vitreous, or spreads to all the tissues of the eyeball. In the former case the inflammatory symptoms subside, the pain lessens, the intra-ocular tension is lowered, and the eyeball gradually shrinks.

In the latter case the inflammation spreads, the edema of the lids and chemosis of the conjunctiva are intense, the pain severe, and the constitutional symptoms—fever, chills, nausea, and vomiting—are very marked. The inflammation involves Tenon's capsule, and causes protrusion of the globe, which is pressed against the swollen lids until these can scarcely be separated on account of the swelling and edema. Finally, rupture of the sclera or sloughing of the cornea occurs, the purulent matter finds a vent, the pain subsides, and in about six weeks the ball is soft, sightless, shrunken, and free from

pain. This second outcome of purulent choroiditis is known as *panophthalmitis*, and the ultimate result as *phthisis bulbi*.

**Causes.**—Purulent choroiditis is caused by the introduction of pathogenic microbes in the same manner as in purulent cyclitis. It is hence seen as the result of perforating wounds, septic cataract extraction, and sloughing ulcers of the cornea.

Purulent choroiditis is also caused by embolism from a microbic area—*e. g.*, in pyemia, especially in puerperal sepsis, septicemia, and endocarditis. A common cause is cerebrospinal meningitis especially in children, basic meningitis, and it has also occurred in wasting diseases, in dysentery, bronchitis, whooping-cough, measles, and especially in small-pox with corneal complication. Inflammation of the umbilical vein and thrombosis of the orbital veins are known to cause the disease.

**Prognosis.**—This is most unfavorable, and almost invariably blindness with shrunken eyeball is the result of the inflammation. A few cases of recovery from suppurative iridochoroiditis following cerebrospinal meningitis have been recorded. The termination of destructive ophthalmitis in children is usually not fatal, but a few deaths have occurred, generally from meningitis (see also page 454).

**Treatment.**—In the early stages antiphlogistic treatment may be of service in robust cases—blood-letting from the temple, a sedative fever mixture, with sufficient morphin to relieve pain, and locally, frequently changed ice compresses. In later stages hot fomentations are better, a square of lint being soaked in heated bichlorid solution; and internally, opium and quinin in full doses. If there is much pain before spontaneous rupture has occurred, a free incision into the sclerotic will bring relief. Indeed, Noyes advises that while certain cases of panophthalmitis should be treated to the termination of the suppurative process without operation, in the majority of instances deep incisions, with or without enucleation, are the best method of relief, even when the symptoms of meningitis have appeared.

Surgeons differ in regard to the advisability of enucleating the globe during the acute stages of panophthalmitis, some

operators declining to perform excision under such circumstances, in the belief that meningitis is liable to follow, while others do not recognize this danger.

The author does not hesitate to enucleate an eyeball in which there is suppuration if the surrounding orbital tissues are not yet involved in the process; but agrees with Pooley that where the process has reached a great height, where there is purulent infiltration of the orbital tissues, and where the affection has begun posteriorly, as in some varieties of septic iridochoroiditis, the operation of enucleation is surrounded by dangers. In a certain number of cases it has been

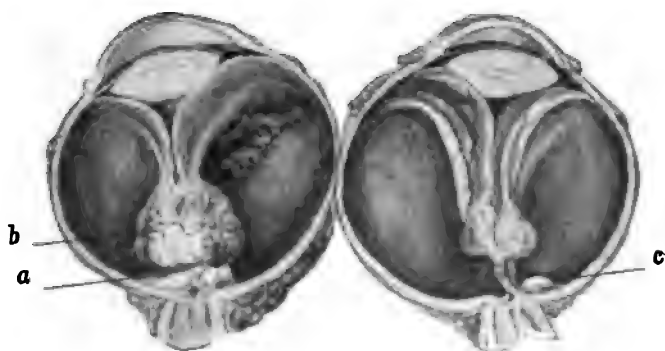


FIG. 126.—Leukosarcoma of choroid, showing at (a) constriction which marks where choroidal capsule was ruptured and where retina became adherent, being pushed forward with growth of upper part of tumor (b), which assumes a mushroom shape. At (c) choroidal origin of growth is seen.

followed by meningitis. Therefore under these conditions evisceration is preferred. But even after evisceration there may be a great accumulation of inflammatory products behind the scleral cup, and to these a vent must be given.

**Tumors of the Choroid.**—The most frequent neoplasm of the uveal tract, and, for the present purposes of description, of the choroid, is *sarcoma*. Most commonly it appears as a pigmented growth (*melanosarcoma*); more rarely (one in eight, according to W. C. Rockcliffe) without pigment (*leukosarcoma*).

Sarcoma of the choroid, according to E. Paüel, is most frequent between the ages of fifty and sixty. A good many cases, however, occur at an earlier period than this, but the

disease is rare under the twentieth year. Men are more frequently affected than women, and the left eye, according to some statistics, is more apt to be involved than its fellow.

**Pathology.**—The growth usually is circumscribed, and has a spheroid form as long as the choroidal capsule remains unbroken. Sometimes it assumes a cake-like shape, and occasionally the form of a mushroom. Rarely, there is a diffuse sarcomatous infiltration of the choroid.

Sarcoma of the choroid is almost invariably a primary



FIG. 127.—Macroscopic appearance of a pigmented choroidal sarcoma—flattened growth or so-called cake-like form. One extrascleral nodule.

growth; but the choroidal coat may be, though very rarely, affected by a metastasis occurring from a tumor in some other portion of the body—for example, the mediastinum (A. V. Meigs and the author).

The tumor develops from the outer layers of the choroid, and grows inward, detaching the retina. The cells are round or spindle formed, or occasionally of a large endothelioid type, when they develop from the endothelial linings of the lymph-spaces. They are usually pigmented, the density of the pigmentation depending upon the participation of the

choroidal stroma cells in the proliferative process. Usually there are many broad vessels, around which the cells may be grouped. In the second stage secondary glaucoma occurs, and occasionally plastic iridocyclitis appears and results in atrophy of the globe. A tumor may grow in a phthisical eye, and, as Leber has pointed out, an eye which is the seat of a growth may become phthisical and the tumor itself cease to grow for a time. Coppez divides the primary new growths of the choroid into—(1) *Interfascicular endotheliomas* which develop from the *endothelial* cells of the lymph-spaces; (2) *peritheliomas* (angiosarcomas) which arise from the perithelial cells of the blood-vessels; (3) *sarcomas* of various characters which grow from the proper cells of the choroid and the adventitia of the blood-vessels. *Alveolar sarcomas*, also called endotheliomas or intravascular angiosarcomas, are rare as compared with perivascular sarcomas of the choroid. It is probable that in these alveolar forms the greater mass of the tumor is formed by the proliferation of endothelial cells (Posey and Shumway).

**Symptoms.**—The life history of a sarcoma of the choroid has been divided by systematic writers into four periods: The first, the quiet period; the second, the inflammatory period; the third, the extra-ocular period, or that stage when the growth bursts through the scleral boundary; and fourth, the period of metastasis.

In the *first stage* the disease resembles a detachment of the retina, this membrane being pushed forward by the underlying elevation, the whole being surrounded by a serous effusion. Beneath this retinal covering the brownish mass may sometimes be recognized, covered by irregular choroidal vessels, a point, however, not always ascertainable if the original growth is of the non-pigmented variety. If the growth is situated far forward, it is sometimes possible to examine it by means of oblique illumination through a dilated pupil. There is a corresponding defect in the field of vision, and the sight of the affected eye is diminished in accordance with the situation of the tumor. Should this be peripheral, the central vision at this stage may not be seriously affected. The

first stage usually lasts from six to twelve months, but rarely may be prolonged to five years.

In the next period of the history of this growth, or the *inflammatory or glaucomatous stage*, symptoms of increased tension which depend upon alterations in the angle of the anterior chamber arise: pain in the brow, anesthesia of the cornea, shallowing of the anterior chamber, and dilatation and tortuosity of the perforating episcleral vessels. Ophthalmoscopic examination is no longer possible, the localized detachment of the retina becomes general by increased serous effusion, the lens may become cataractous, and a severe iridocyclitis may be set up.

As the growth continues, the sclera becomes ruptured and the surrounding tissues are involved (*fungus state or stage of episcleral tumors*). It may pass backward into the brain, or secondarily affect the optic nerve, but more commonly the last, or *metastatic stage (stage of generalization)* develops, when distant organs are attacked by growths of similar histologic character, the liver far more frequently than other organs, but also the spleen, intestines, and even the lungs. Metastasis to the liver need not necessarily be delayed until the tumor has burst, at least visibly, through the scleral boundary. One of the most extensive cases of secondary sarcoma of the liver which has come under the writer's notice was in connection with a small sarcoma of the choroid, in which there was no external manifestation, but in which a few fragments in the orbital tissues appeared to be of suspicious nature after the removal of the eye.

**Diagnosis.**—It is necessary to differentiate sarcoma of the choroid from glioma of the retina. To this reference will be made in a future section.

In the early stages choroidal sarcoma may be mistaken for idiopathic detachment of the retina and detachment of the choroid. In retinal detachment there is usually a history of sudden onset, and the ophthalmoscope may reveal undulations of the folds of the detached retina with the movements of the eye, vitreous opacities, and signs of choroiditis. Moreover,

the field is frequently less sharply defective than in choroidal sarcoma.

Choroidal detachment is rare, the history is different from that of sarcoma, and the characteristic vessels of the choroid can usually be recognized beneath the vessels of the retina.

Too much reliance cannot be placed upon the tension of the eyeball as a distinguishing sign between sarcoma and retinal detachment, because intra-ocular tension may be unaltered in each instance, although, as C. Devereux Marshall has shown, it is probably never diminished (as it often is in retinal detachment) in undoubted cases of choroidal sarcoma, while it may be reduced in cases of sarcoma of the ciliary body.

In the stage of increased pressure the disease is to be distinguished from glaucoma by observing the suddenness of the onset of inflammatory symptoms—in the latter disease without antecedent history of poor vision—and the fact that in the glaucomatous eye there are remissions in the acute symptoms, and that the tension is somewhat amenable to the myotics.

**Prognosis.**—Removal of an eye for choroidal sarcoma results in a cure in from 25 to 30 per cent. of the cases, although statistics on this point vary greatly. Metastasis to internal organs is the most usual cause of death and generally takes place within two years after operation. According to Fuchs, the stage at which enucleation is performed does not influence the occurrence of metastasis; indeed, Pawel declares that metastases are relatively more frequent after early enucleations. It is usually stated that very vascular and round-celled sarcomas are more fatal than other varieties. Prognosis is better in young than in aged subjects. Local recurrence is much less frequent than metastasis; it is prevented by prompt removal of the eye. If there is no recurrence or metastasis within four years after enucleation of the eye, this complication becomes unlikely, although exceptions to this rule have occurred, and metastasis has been noted even after seven years.

**Treatment.**—From what has been said it is evident that the only treatment is prompt enucleation. The optic nerve should be severed as far back in the orbit as is possible.



It may be necessary to remove the entire contents of the orbit.

Rare forms of tumor of the choroid are the following: *Cavernous angioma, telangiectatic sarcoma, adenoma, and enchondroma.*

**Carcinoma of the Choroid.**—About 30 cases have been reported, 7 being bilateral. Of the unilateral cases, 9 were of the left eye. The tumor is of rapid development and generally appears as a flat growth in the neighborhood of the macula. In the majority of instances it represents a metastasis from a carcinoma of the mammary gland; the primary neoplasm has also been situated in the lungs, pleura, stomach, and thyroid.

**Tubercle of the Choroid.**—Tubercles appear in the choroid as yellowish-white spots, varying in size from 1 to 1.5 mm., occasionally larger, and usually, though not necessarily, associated with similar growths in the meninges. Repeated examination is required for their detection, and even then they may escape observation, owing to their diminutive size ("*choroidal dust*"). They have been frequently found in post-mortem examinations.

Tubercles, known as miliary tubercles, are distinguished chiefly by their color, which has been described as of a dull, yellowish-white in the center, encircled by an ill-defined rose-colored area (Horner). Usually there are no pigmentary changes in the immediate neighborhood, but pigment bodies may surround the nodules, if they are prominent (Bach). They are situated usually near the optic disc or in the macular region, and vary in number from three to six, or many more.

Instead of the miliary growth, a single large *tubercular tumor* may appear and progress, producing the same destructive changes as a sarcoma. It may be associated with a similar one in the brain.<sup>1</sup>

<sup>1</sup> *Chronic choroidal tuberculosis* is characterized by optic neuritis, optic atrophy, hemorrhages (tuberculous inflammation), and a diffuse, yellowish-white discoloration, occupying a considerable area of the eye-ground, within which are round, yellowish-white spots. Michel describes tuberculous granulation tumors of the choroid, which begin with the appearance of retinal detachment, and later cause abscess in the vitreous and shrinking of the eye.

**Treatment.**—Miliary tubercles of the choroid do not require any treatment directed to the eye itself, the vision of which may not be seriously affected. If a single large choroidal tumor were recognized, and the patient's general condition permitted it, enucleation to avert general tuberculosis would seem to be a proper procedure.

**Injuries of the Choroid.—Wounds of the Choroid.**—Necessarily in a perforating wound of the sclera, the choroid is also lacerated or incised, and no description other than that already given in this connection is required.

**Foreign Bodies in the Choroid.**—A penetrating foreign

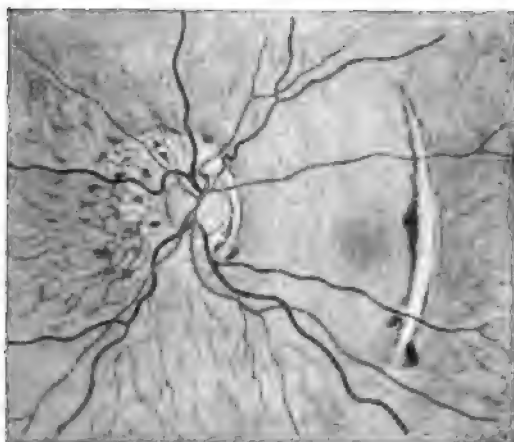


FIG. 128.—Rupture of the choroid (from a patient under the care of Dr. Randall in the Children's Hospital).

body may lodge in the choroid, and then the treatment described on page 334 is applicable.

**Rupture of the Choroid.**—The most important injury to which the choroid is subject, and which follows a blow upon the eye, is rupture. This generally manifests itself in a sickle-shape crescent, commonly on the temporal side of the disc, rarely on the nasal side, and which very seldom extends in a horizontal direction. The rupture may be single or multiple, and sometimes is composed of several branches. The immediate effect of the blow is a hemorrhage preventing distinct observation. When this has disappeared, the fissure is evi-

dent to the ophthalmoscope as a yellowish-white stripe bordered with some disturbed pigment (Fig. 128).

The ruptures usually run concentrically with the papilla.

They may be either complete or incomplete, and may, or may not, be associated with breakage of the overlying retina. In rupture confined to the choroid, the retinal vessels pass over it. If the retina has also given way there is apt to be more hemorrhage than without such accident, and no retinal vessels are observed crossing the choroidal separation. Associated with choroidal rupture there may be a rupture of the sphincter of the iris (Duane and the author).

The ultimate effect on vision depends upon the size and situation of the rupture. At first there is very considerable disturbance of sight, partly due to effusion, and partly to injury of the iris, sometimes associated with blood in the anterior chamber. This slowly clears away, and very good vision may result, provided the change in the eye-ground has not been extensive. A deterioration of vision may occur a long time after such an injury, owing to secondary changes in the optic nerve.

*Treatment.*—The pupil should be dilated with atropin; if there is much pain, a leech or two should be applied to the temple, a pressure bandage adjusted, and the patient put to bed. These measures suffice to encourage the absorption both of the blood and of the serous effusion.

**Hemorrhage into the Choroid.**—In the section on unclassified forms of choroidal disease, variously shaped hemorrhages which appear in this membrane, and which by absorption give rise to atrophic spots, have been described. In like manner there may be hemorrhage from the choroid, the result of a blow. A choroidal hemorrhage may be distinguished from one situated in the retina by noticing the more diffuse character of the extravasation and the fact that the retinal vessels pass over it, but the diagnosis is difficult.

**Detachment of the Choroid.**—This is a rare condition. It may be idiopathic or traumatic, partial or complete. The detachment may be caused by blood, serum, a layer of lymph,

or a new growth. Cases following cataract extraction have been reported.

**Ossification of the Choroid.**—This is occasionally found in eyes long blind and shrunken from destructive iridochoroiditis. The formation of bone occurs in the inflammatory tissue, and may be recognized by palpation in the form of an irregular plate, spicule, or complete shell. Calcareous degeneration is common in eyes of this character. The eyeball should be enucleated.

**Atrophy of the eyeball** is a condition characterized by diminution in the size of, and alteration of the shape of, the globe, caused by contraction of inflammatory exudates—for example, those formed in the uveal tract. It should be sharply distinguished, according to Fuchs, from *phthisis bulbi*, which results from a suppurative inflammation (see page 392) and is associated with rupture of the sclera and partial evacuation of the ocular contents. The former may give rise to sympathetic irritation; the latter usually, but not always, is harmless.

**Essential phthisis bulbi** (*ophthalmomalacia*) is the name applied to a condition of the eye characterized by hypotony (softening) and diminution in its size which is unrelated to inflammation. There may be photophobia, pain, myosis, and partial ptosis. An intermittent variety has been described. It may follow injury and be connected with disease of the sympathetic.

## CHAPTER XII.

### GLAUCOMA.

**Glaucoma** is the name applied to several varieties of a disease of which increased intra-ocular tension is the most characteristic sign.

**Varieties of Glaucoma.**—(1) *Primary glaucoma*, or that form which arises without antecedent disease of the eye, and (2) *secondary glaucoma*, or that form which occurs as the sequel of a preexisting ocular disease, often an inflammation of the uveal tract.

The primary variety of this disease may be divided into—(1) *Acute glaucoma* (acute inflammatory glaucoma); (2) *sub-acute* or *chronic congestive glaucoma* ("glaucoma irritatif," chronic inflammatory glaucoma); (3) *chronic non-inflammatory glaucoma* (simple chronic glaucoma).

**Symptoms.**—The following is a syllabus of the symptoms common to the disease glaucoma, though not constantly present in each variety:

1. *Rise in intra-ocular tension*, or increased hardness of the eyeball, varying from T? ("stiffened sclera") to T + 3 ("stony hardness"). In the former a positive rise of tension may be doubtful, the sclera simply presenting more than the usual resistance to the palpating finger; in the latter, firm pressure fails to produce impression. Intermediate degrees are T + 1 and T + 2.

This increased hardness of the eyeball may be measured by an instrument known as a *tonometer*, but in practice is estimated by palpating the globe with the finger-tips in the manner described on page 97.

2. *Change in the Size and Shape of the Pupil and Mobility of the Iris.*—The pupil may be round, oval, or egg-shaped, semi-dilated, or expanded to its fullest limit; the iris sluggish in

movement, or entirely inactive. In simple glaucoma abnormal pupillary symptoms may be absent.

The pupillary space sometimes transmits a greenish reflex (hence the name given by the older writers) from the surface of the lens. The dilatation of the pupil is explained by paresis of the ciliary nerves or by constriction of the vessels of the iris.

3. *Loss of the Transparency of the Cornea.*—The cornea somewhat resembles the appearance of glass, the surface of which has been dulled by being breathed upon. This haziness is marked in the congestive types of glaucoma, but is absent or only slightly present in the simple varieties. If the cornea is carefully examined, the cloudiness will be found more decided in the center, and will resolve itself into very numerous closely aggregated points, the whole presenting a stippled or "needle-stuck" appearance. Iritis and iridochoroiditis may produce a similar appearance (Schweigger). The condition is caused by edema of the cornea.

4. *Change in the Depth of the Anterior Chamber.*—This symptom varies from an almost imperceptible shallowing to a complete obliteration. While it is not customary to divide the various grades of narrowing of the anterior chamber into degrees, as has been done with tension, such a division might include doubtful loss of depth, moderate loss, great narrowing, and complete obliteration. During the course of glaucoma the lens system and peripheral portion of the iris are pushed forward, and this causes the depreciation in the depth of the anterior chamber.

5. *Change in the Normal Appearance of the Iris and Turbidity of the Aqueous and Vitreous.*—The same edema which affects the cornea may also cause loss in the characteristic markings of the iris, so that its pattern becomes indistinct, especially in congestive forms of glaucoma. The veins of the iris may be dilated and tortuous; small hemorrhages are sometimes visible. Opacities in the media also are liable to form, and the lens itself may become cataractous.

6. *Alterations in the Conjunctival and Episcleral Vessels.*—In acute glaucoma there are usually general hyperemia and

often edema of the conjunctiva, but in chronic inflammatory and sometimes even in simple glaucoma, there are marked enlargement and tortuosity of the episcleral venous branches (System II., page 58).

7. *The Excavation of the Nerve-head and the Surrounding Yellowish "Halo," or "Glaucomatous Ring."*—Under the influence of the increased intra-ocular pressure, the most impressionable portion of the eye—the intra-ocular end of the optic nerve—gives way, and the glaucomatous cup is produced. According to Knies, congestion and edema of the nerve-head precede cupping, and according to Brailey and Edmunds, actual neuritis appears in advance of increased tension. The author and Gasparini have seen excavation of the papilla follow retrobulbar neuritis.

The cupping of the optic disc is seen with the ophthalmoscope, and its depth is measured according to the directions given on page 124. It is also recognized by employing the *parallax test* with the indirect method as follows: The optic nerve is found in the usual manner by the inverted image, and the object lens moved from side to side. The entire eye-ground apparently moves with the motions of the lens, and the bottom of the excavation also seems to move in the same direction, but at a much slower rate. The contrast in the rate of the two movements is in a direct ratio with the depth of the excavation.

The cup varies from one beginning to be pathologic to a fully formed excavation. In the latter instance the excavation is complete to the scleral margin, and its edges are abrupt; the vessels are crowded to the nasal side, bend sharply over the margin, and are lost to view behind the border of the cup, reappearing in fainter color at its bottom.

The papilla is encircled by a yellowish ring due to atrophy of the surrounding choroid.

It is important to distinguish between a large physiologic cup, an excavation due to atrophy of the optic nerve, and the glaucomatous cup. A physiologic excavation is partial and formed in a normally tinted nerve-head; an atrophic excavation is complete, shallow, and formed in a nerve-head of abnormal

whiteness, owing to its loss of capillarity; and a glaucomatous excavation is complete, deep, and often of greenish hue. The microscopic appearances of a nerve-head containing a deep glaucoma cup are shown in Fig. 130 (consult also Fig. 129).

The descriptions thus far given apply to typical forms of each variety of excavation. Sometimes it is a matter of considerable difficulty to decide between them, especially between an atrophic and a glaucomatous excavation when the latter is shallow; or between a physiologic excavation and glau-

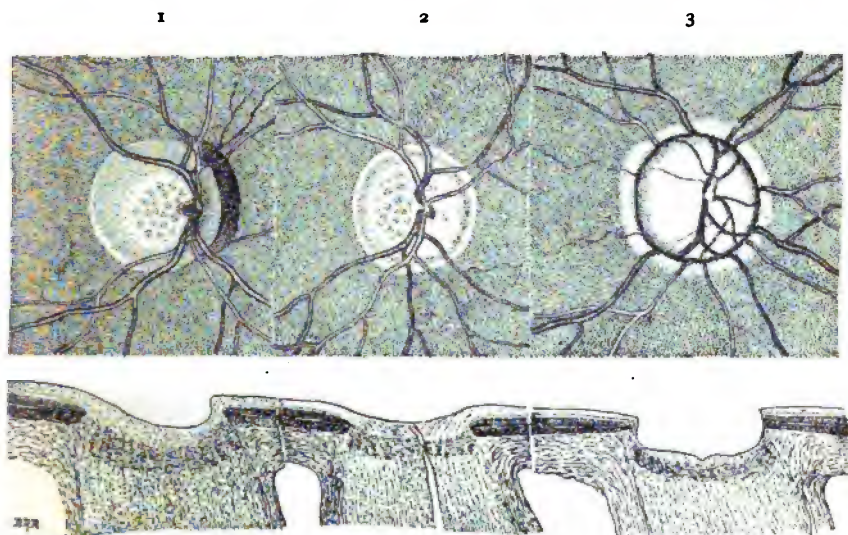


FIG. 129.—Excavations in nerve-head: (1) Physiologic, (2) atrophic, and (3) glaucomatous excavations (Randall).

coma, when the former is associated with primary optic nerve atrophy (Schweigger). A diagnosis must then be based upon an examination of the other symptoms, particularly the field of vision.

*8. Vessel Pulsation on the Surface of the Disc.*—(a) *The Veins.*—There is often marked venous pulse, especially at the dark knuckles of the veins as they bend over the margin of the excavation, but this is a common ophthalmoscopic appearance in healthy eyes (page 116), and hence cannot be utilized as a diagnostic symptom.



(b) *The Arteries*.—Pulsation of the arteries is a rare appearance except in aortic regurgitation, and therefore may be regarded as an important indication of increased intra-ocular tension, in high degrees of which it is a striking symptom, the arterial trunks on the surface of the disc showing rapid alternate filling and collapse. It is usually, but not always, confined to the disc. The cause of spontaneous arterial pulsation resides in the resistance to the passage of the blood through the vessels, a resistance which in turn depends partly upon in-

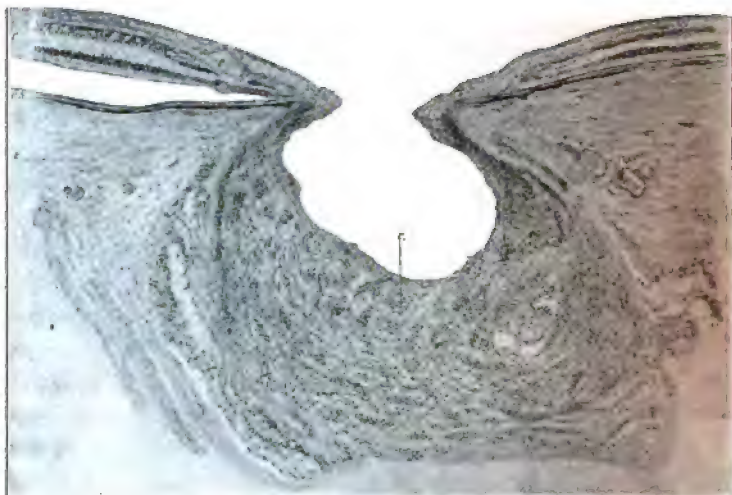


FIG. 130.—Section of optic nerve-head containing a deep glaucomatous excavation, the so-called kettle-shaped excavation: *r*, Retina; *ca*, choroid; *s*, sclera; *c*, cup, or excavation, pushing back lamina cribrosa.

creased tension and partly upon spasmodic contraction of the vessels themselves. In cases of glaucoma in which this pulse is not spontaneously visible, it may be induced by slight pressure upon the globe.

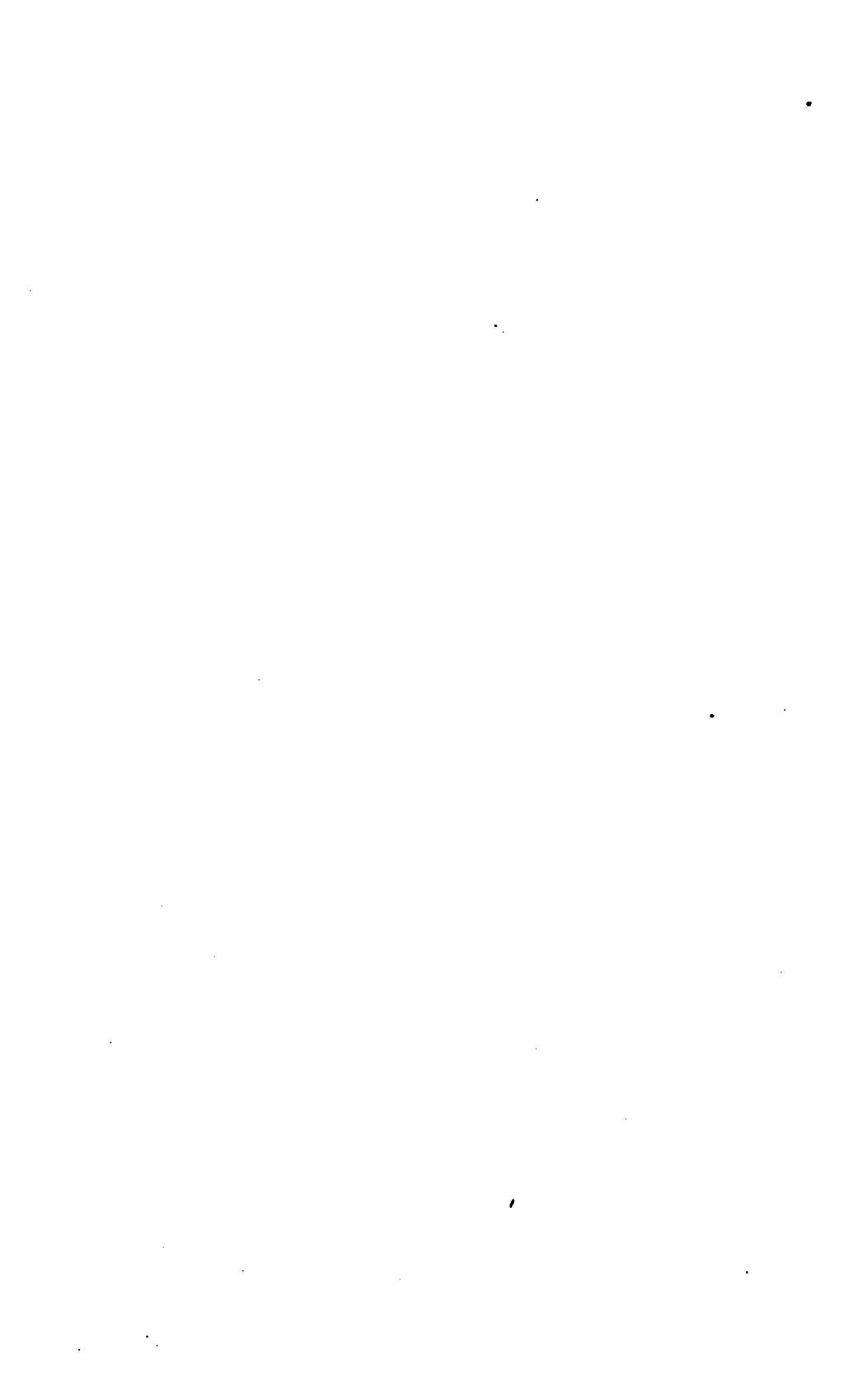
In addition to the *objective* signs of glaucoma just described, certain *subjective* symptoms are more or less constantly present.

1. *Pain*.—In acute attacks the pain is a severe neuralgia of the trigeminal distribution, and often, in violent congestive cases, an intense agony associated with great depression, pallor of the countenance, nausea and vomiting. In subacute

PLATE II.



The fundus of an eye with chronic glaucoma.



attacks there is a less marked similarly located pain. In chronic cases there may be only a general feeling of discomfort, a sense of fullness, occasional shoots of neuralgia, or attacks described by the patient as headache.

2. *Alteration in the Sensibility of the Cornea.*—Anesthesia of the cornea, when present, varies from a slight depreciation in its sensitiveness to an entire loss of sensation, as complete as that produced by cocain. Sometimes the anesthesia is not uniform over the surface of the cornea, but exists in spots or segments. It is due to the edema of the structure, which presses upon the filaments of the corneal nerves.

3. *Alterations in Central Visual Acuity.*—This symptom varies considerably, and in chronic cases excellent sharpness of sight may be preserved for a long time. It is important to remember this, because it is not safe to depend upon central vision as a guide of the rate of progress of a chronic glaucoma. In each attack of subacute glaucoma the vision quickly fails, and gradually is recovered as the attack passes away. Each recurrence leaves a more permanent impression. In acute glaucoma, a characteristic symptom is the sudden loss of vision, which in a few hours may be reduced to a light perception, and in certain malignant types rapidly becomes absolute.

4. *Alteration of the Refractive Power of the Eye and Diminution of the Amplitude of Accommodation.*—The former depends upon the change in the shape of the cornea; and the latter upon the effect of pressure upon the ciliary nerves. A very important event in chronic glaucoma is the changing of an astigmatism "according to the rule" to one "contrary to the rule," while the diminished power of accommodation is evidenced by the desire of patients to change their reading-glasses to such as are stronger than the degree of refractive error or age of life would warrant.

5. *Alteration in Peripheral Vision, or the Field of Vision.*—A careful map of the field of vision in glaucoma is indispensable, and the restrictions present themselves in several forms: (a) The most usual and typical variety is partial or complete loss of the nasal field or of the upper or lower quadrant of the

nasal side; (*b*) concentric restriction of the entire field; (*c*) restriction so constituted that the remaining field assumes an oval or trowel shape; (*d*) sectional defects, often of the supero-

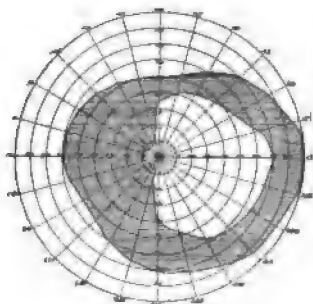


FIG. 131.—Field of vision of right eye in a case of subacute glaucoma. Loss of the nasal half and concentric restriction of the preserved field.

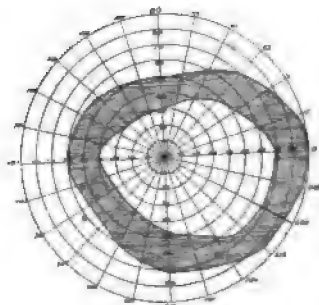


FIG. 132.—Field of vision of right eye in a case of chronic glaucoma, showing concentric restriction of the field.

nasal area; (*e*) loss of the entire field except a patch on the temporal side; (*f*) the formation of scotomas, which may be central, paracentral, annular, or peripheral (Figs. 131-137).

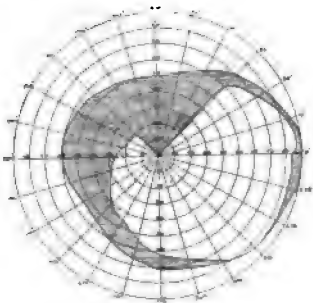


FIG. 133.—Field of vision in right eye in case of chronic glaucoma, showing sectional defect (supero-nasal quadrant).

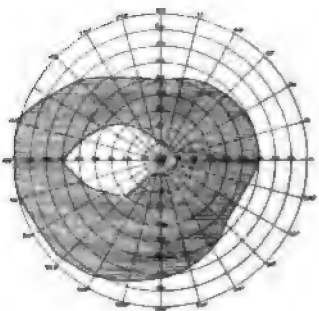


FIG. 134.—Field of vision of left eye in chronic glaucoma. Trowel-shaped patch preserved chiefly on the temporal side.

The contraction of the color-fields is usually proportionate to that of the form-field, but this rule meets with exceptions. Under the influence of operative measures or myotics very

decided improvement in the extent of the visual field may take place.

The tendency of the visual field is to contract progressively

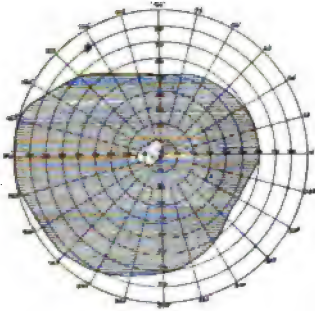


FIG. 135.—From the same case as Fig. 134, six months later; only a small patch of preserved field on the temporal side.

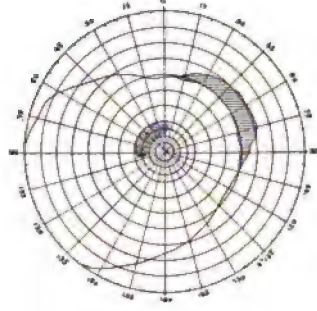


FIG. 136.—Just beginning contraction of nasal field; scotoma extending from blind spot in a semi-circular manner upward and inward.

as the disease advances, and finally all portions are obliterated except a small part upon the temporal side, which also disappears in the ultimate blindness (consult Fig. 135).

The contraction of the field of vision is an important index of the rate of progress in glaucoma, more important than de-

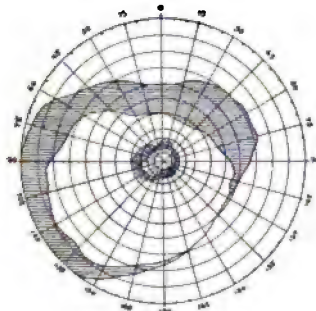


FIG. 137.—Annular scotoma in chronic glaucoma; moderate contraction of the peripheral field.

preciation of central vision; but it is not sufficient to trust to the periphery of the field for information. A search for *scotomas* is imperative. There is no difficulty in finding them,

either by the method suggested by Bjerrum (page 91) or by ordinary perimetric methods, when care is taken to investigate each meridian and suitable test-objects are employed under varying degrees of illumination. Doubtless, as Bjerrum has pointed out, these scotomas are the result of the destruction of the fibers of the papilla at the margin or sides of the excavation, but sometimes they are to be accounted for by alterations in the inner retinal layers. They are topographically different from those which occur in simple optic nerve atrophy, and may be utilized as a differential test between the two conditions, as Bjerrum has already suggested. This

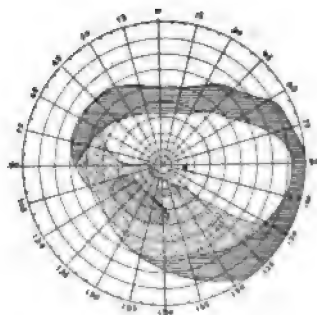


FIG. 138.—Visual field of right eye in chronic glaucoma, showing the mechanism of the loss of the lower and inner portion of the field, preceded by a scotoma, which gradually extends. Scotoma represented by parallel lines; area of dull vision which subsequently is completely lost, by dots.

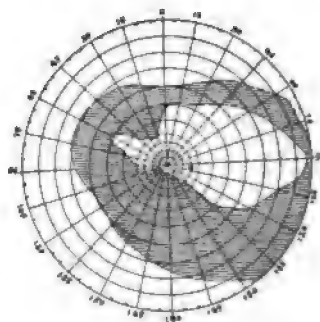


FIG. 139.—Later stage of Fig. 138. The scotoma has extended, and the area of the visual field in which sight was only dulled, and which is represented by dots in the preceding figure, has become completely dark.

writer believes, and his observations have been confirmed by Meisling, that these scotomas are peculiar in that they spread over the periphery in all directions, sometimes more in one direction than in another, except outward, where they never pass beyond the blind spot. In other words, the defective area, wherever situated, is in direct continuity with the blind spot. The author has not always found this direct continuity, but the scotomas are certainly very commonly present. They are often the forerunners of subsequent defects in the periph-

eral visual field (Figs. 138, 139). The field of vision is not normal because its periphery has its full extent. No field is mapped until each meridian has been examined from fixation point to periphery when dealing with cases of chronic glaucoma.

**6. Iridescent Vision.**—This consists of a definite ring surrounding artificial lights, which thus become invested with a colored halo ("halo vision"). First there is a dark band, followed by a concentric zone of prismatic colors, violet within and red without.

This phenomenon has been attributed to various causes depending upon physiologic or physical effects. Experimental evidence tends to support the opinion that the cause resides in the cornea, and depends on alterations in its epithelium, the result of exaggerated pressure.<sup>1</sup>

Subjective sensations of light are experienced at times by totally blind glaucomatous patients. The explanation is probably a mechanical one, and the sensation depends upon a dragging on the retina. In one case noted by the writer, both eyes being blind from glaucoma, the patient declared "all things seemed to be a sea of red fire."

The clinical varieties of glaucoma may now be described.

**I. Acute Glaucoma** (*Inflammatory or Congestive Glaucoma*).—This type of the disease is suitably divided into two stages:

**(a) Period of Incubation, or Prodromal Stage.**—This is characterized by sudden failure in the amplitude of accommodation, with a desire to resort to stronger reading-glasses; temporary obscurations of vision, either dim vision or quite complete loss of sight, lasting for many minutes; attacks of foggy vision, due to increased intra-ocular tension, all things apparently being invested with a haze; and the phenomena

<sup>1</sup> According to Schweigger, halo vision occurs in mild attacks of iritis with slight deterioration of vision. It may also be caused by a layer of mucus overspreading the cornea during chronic conjunctivitis. According to Myles Standish, the halo due to mucus has only the outer or red and yellow bands. The presence of blue in the halo may, therefore, be regarded as indicating increased intra-ocular tension.



of colored halos around artificial lights. There may be some periorbital pain, the pupil is slightly dilated, and the cornea and the aqueous humor faintly turbid. The appearance of the optic nerve at this stage is not characteristic.

These prodromes bear some relation to emotional excitement and insomnia, and may occur when the head is congested, or after a full meal. After the eye regains its natural state, in a week or two the symptoms may reappear, again to subside and to be replaced by a fresh exacerbation or a true "glaucomatous attack." The incipient period of glaucoma may last one or more years.

**(b) Period of Attack, or the "Glaucomatous Attack."**—This commonly begins during the latter part of the night, sometimes having been preceded by prodromes, but sometimes without previous warning, and is characterized by violent pain in the head, so severe that it may induce nausea and vomiting. The face may be pallid, the extremities cold, or there may be flushing and general fever. The eyelids are swollen, the conjunctiva injected and sometimes chemotic, the cornea steamy and anesthetic, the pupil semidilated and motionless, the aqueous turbid, and the iris discolored. The tension rises very high,  $T + 2$  or  $+ 3$ , and vision is rapidly lost, often only light-perception remaining, and even this may be abolished. Sometimes the attack is bilateral, or only a few hours elapse before the second eye is attacked. Again the interval between the two eyes may last weeks, months, or even years.

Gradually the symptoms pass away, with the exception of slight impairment in the mobility of the iris, some limitation of the field, and a little rise in tension. Blindness almost never occurs in the first onset. At this time characteristic ophthalmoscopic appearances are not present. After some weeks or months these phenomena reappear. After a number of attacks, examination of the eye-ground during a remission (the fundus is not visible during an attack) may reveal the characteristic cupping, the halo, and the arterial pulse.

If the disease is unchecked, the eye passes into a *glaucomatous state*, with fixed and dilated pupil, discolored iris,

## Subacute or Chronic Congestive Glaucoma 413

greenish reflex from the lens, vitreous opacities, shallow anterior chamber, and hazy cornea. Vision is now gradually destroyed and the eye reaches the *state of absolute glaucoma*, when the ball is stony hard, the iris atrophic, the lens cataractous and pushed forward, the anterior chamber obliterated, the sclera discolored, the episcleral vessels coarsely injected, the cornea opaque, or perhaps ulcerated. Finally, there is disorganization of all the structures of the eyeball, and the sclera gives way with the formation of staphylomas, or the eyeball slowly atrophies as the result of choroiditis, change in the vitreous, and detachment of the retina. Acute glaucoma, instead of pursuing this course, occasionally passes into a chronic inflammatory type.

*Glaucoma fulminans* is the name applied to an aggravated, rare form of the acute disease, in which the symptoms may be fully developed in a few hours without a prodromal stage. There is no remission, and the destruction of vision is swift and permanent.

### **2. Subacute or Chronic Congestive Glaucoma.—**

This type, like its predecessor, may or may not begin with certain prodromal signs. These, when present, become more pronounced and the eye gradually passes into a stage characterized by the constant presence of a series of symptoms which are often described under the title *chronic inflammatory glaucoma*.

The cornea is deficient in transparency or positively steamy; there are marked tortuosity of the episcleral veins and some discoloration of the scleral tissue; the aqueous humor is turbid and the deeper media present opacities; ophthalmoscopic examination, when it is possible, reveals the cupped disc and pulsating vessels; the tension of the eye is raised; the pupil is semidilated, and the iris sometimes atrophic and sometimes not. Hence two types of chronic inflammatory glaucoma are described, one associated with degenerative changes in the iris and one without such association.

The field of vision is either contracted upon the nasal side or a quadrant of the field is darkened.

During the course of the disease acute or subacute attacks

supervene; that is, there are sharp ciliary pain, increased steaminess of the cornea, increased injection of the eyeball, sinking of the vision, exaggeration of the tension, and marked anesthesia of the cornea. The attack then passes away and in a few days or weeks repeats itself. Sometimes instead of a subacute attack of this character, an acute congestive exacerbation occurs, in all respects resembling the disease just described, and like it ending in absolute glaucoma or in degeneration of the tissues of the eye. This disease may last from several months to a year.

**3. Chronic Glaucoma or Non-inflammatory Glaucoma** (*Usually Known as Simple Chronic Glaucoma*).—This type of the disease is characterized by an absence of the signs of glaucoma in the anterior aspect of the eye, at least on ordinary inspection. By careful examination, slight steaminess of the cornea may sometimes be detected, with a little lack of transparency in the aqueous humor. So, too, there may be some undue tortuosity of the perforating branches of the episcleral plexus. In general terms, however, there is an absence of congestive symptoms and there is no pain. The tension of the eyeball is always increased at some period of the disease, but this symptom is not constantly present, or it may be present at one portion of the day and not at another. The depth of the anterior chamber is not materially altered. The chronic simple variety of glaucoma sometimes resembles chronic congestive glaucoma and vice versâ. If, according to de Wecker, in the affected eye corneal involvement is made evident by nebulous vision, halos, etc., or, in other words, by irritative attacks, the case ceases to be one of simple glaucoma, and is to be grouped with the chronic congestive types.

Almost without exception both eyes are affected simultaneously or successively; but it is difficult to fix the exact date of the onset of this variety of glaucoma, because of the absence of pronounced prodromal symptoms which precede the other types of this disease.

If both eyes are affected, the one is usually more advanced than the other, and then the pupil will generally be slightly larger on the side of the greater disease. In the

later stages a greenish sheen from the pupil is often distinct. The central vision may be good, and in the earlier stages of the disease, after the correction of any refractive error, may reach nearly the normal standard.

The media are clear, and the disease is detected with the ophthalmoscope, by observing the characteristic cup in the nerve-head, the halo surrounding it, and the spontaneous arterial pulse, or its ready development by slight pressure.

The field of vision gives important information, and it assumes one or other of the characteristics described on page 408 (Fig. 131-139). The central color perception is good, and the contraction of the peripheral color perception corresponds with that of the form-field.

Simple chronic glaucoma may assume a subacute or an acute nature like that already described, but the typical varieties progress to blindness without aggressive symptoms, having simply the characters of *optic nerve atrophy with excavation*, from which they should be distinguished by the presence of increased tension.

**Causes.**—(a) *Predisposing Causes.*—Primary glaucoma is rare before the fortieth year; not 1 per cent., according to Priestley Smith, begins earlier than the twentieth year. Of these a few, generally monolateral, are seen in children. Jews and Egyptians are said to be peculiarly liable to the disease. The glaucomatous eye is usually hyperopic, although Priestley Smith's statistics do not indicate a striking preponderance of this refractive state. There is a relation between smallness of the cornea and glaucoma. The average horizontal diameter of the normal cornea is 11.6 mm., of the glaucomatous cornea 11.1 mm. (P. Smith). Story's measurements yield an average of 11.9 mm. A large lens is a predisposing factor, and small eyes, in which the lens may be disproportionately large, are more liable to the disease than normal globes.

(b) *Exciting Causes.*—Glaucoma may be excited in eyes predisposed to the disease by worry, insomnia, bronchitis, arterial sclerosis, heart disease, syphilis, gout, influenza, and neuralgia of the fifth nerve. Sometimes it follows injury and hemorrhage into the uveal tract. Overuse of ametropic or

improperly corrected eyes, by causing uveal congestion, may bring on glaucoma in an eye predisposed to the disorder. In a number of instances instillation of mydriatics has caused glaucoma.

Should a patient between his fiftieth and sixtieth year desire to change his reading-glass frequently, or use one stronger than is suited to his age or the condition of the refraction of his eye, there is reason to apprehend the onset of glaucoma. On the whole, the disease is slightly more common in women than in men. Those symptoms which have been described as prodromes are distinctive in themselves, and acquire an importance greater than any probable predisposition.

**Pathogenesis.**—Von Graefe explained the nature of the disease by assuming an inflammatory process—a serous choroïditiis—originating in changes in the blood-vessels, typified by the acute types. Donders regarded irritation of the trigeminus as the factor which gave rise to a hypersecretion of fluid, just as stimulation of the chorda tympani induces excessive salivation, and believed the acute types were the results of increased tension induced by vasomotor influence. These theories were no longer tenable after the discovery of the nutrition processes and the path of the circulation of fluids in the normal eye.

It has been demonstrated by Leber that the ciliary body is the chief secreting organ of the eye, and the current is thus described by Snellen :

“The freshly secreted fluid stands in close osmotic relation to that which is contained within the thin membranes of the vitreous body. A slight excretion of fluid occurs at the back of the eye from the vitreous body into the lymph-spaces of Schwalbe in the optic nerve. The chief stream passes over the lens and through the pupil into the anterior chamber, traverses the latter to reach the angle formed by the junction of the iris and the cornea, passes through the meshes of the ligamentum pectinatum, and by diffusion and filtration is taken up into the plexus of veins known as Schlemm’s canal. There is no direct connection between the anterior chamber and the lymph-spaces, which, according to Schwalbe, exist in Schlemm’s canal. The influence of the nervous system on the pressure of the fluid is indirect. The pressure of the fluid regulates the outflow, so that when the afflux is increased, a compensatory increase of the efflux occurs.”

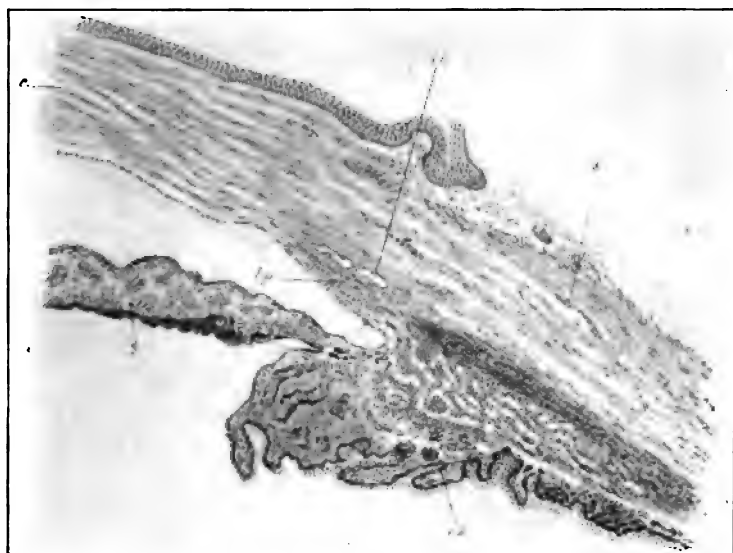


FIG. 140.—Angle of the anterior chamber in a normal eye: *c*, Cornea; *s*, sclera; *i*, iris; *c.b.*, ciliary body; *l.p.*, ligamentum pectinatum; *s.c.*, Schlemm's canal.



FIG. 141.—Angle of the anterior chamber in long-standing absolute glaucoma: *c*, Cornea; *s*, sclera; *i*, iris; *c.b.*, ciliary body; *a.c.*, angle of chamber closed by adhesive inflammation of the iris base to periphery of cornea, obliterating filtration area.

Knies and Weber demonstrated that in glaucomatous eyes, with shallow anterior chambers, there is an adhesion of the iris-base to the periphery of the cornea, which prevents filtration at the angle of the anterior chamber, thus causing retention of fluid (Figs. 140, 141). This discovery developed the theory which is supported by the largest number of advocates. Knies believed that glaucoma originated in an adhesive inflammation of the iris periphery, and, as he has recently stated, may be regarded as an iridocyclitis anterior,<sup>1</sup> while Weber considered this adhesion as secondary to the pressure induced by an abnormally swollen ciliary body. The fact that a mydriatic does harm, by dilating the pupil, rolling back the iris, and partly closing the filtration angle, and that eserine does good, by contracting the pupil and drawing away the iris from this angle, indicates, as Snellen has pointed out, that the explanation of glaucoma is to be found, not in an increase of secretion, but in a disturbance of excretion.

According to Priestley Smith, obstruction of the circumlental space (*i. e.*, the space between the margin of the lens and the surrounding structures) and consequent rise of pressure, may follow increased size of the lens due to advancing years, unusual smallness of the ciliary area in hyperopia, or abnormal enlargement of the ciliary processes. This observer believes that hypersecretion is sometimes concerned in the onset of glaucoma; that serosity of the fluids plays an important part in those forms which present a deep anterior chamber and wide filtration angle; and that obstruction at this angle is part of the glaucomatous attack in the vast majority of cases.

Laqueur and other observers think that glaucoma depends upon obstruction of the intra-ocular lymphatics, which find their way out with the vasa vorticosa, owing to rigidity of the sclerotic coat. Brailey describes a chronic inflammation of the ciliary processes and iris periphery, with distention of the vessels, as the earliest lesion in glaucoma. Stilling believes that a hardening of the sclerotic surrounding the papilla, through which he thinks the waste fluids escape, leads to glaucoma.

<sup>1</sup> He sharply differentiates *simple glaucoma*, which he regards as optic nerve atrophy with excavation, from *true forms of glaucoma*.

The influence of strain upon the accommodation is explained by Snellen as follows: In the young eye, during accommodation for a near point, the diameter of the lens is reduced to about the same extent as that of the contracting ciliary muscle. The circumlental space remains about as wide as it was before, and the zonula remains tense as before. But the conditions are quite different in advanced life, when the elasticity of the lens is lost; the ciliary muscle contracts, but the form and size of the lens remain unchanged. The ciliary process is thereby pressed against the lens and the zonula slackened. Hence the necessity of correction of refractive errors as a preventive measure.<sup>1</sup>

It is evident that there are cases of chronic simple glaucoma not perfectly explainable by any of these theories, and hence there is reason for Knies' desire to separate them from cases of true glaucoma and place them among diseases of the optic nerve. In the present state of our knowledge, however, it does not seem advisable to exclude simple chronic glaucoma from the catalogue of the glaucomas. It is to be distinguished from progressive optic nerve atrophy by the presence of increased tension. If it is true that neuritis precedes cupping of the disc, it is possible, as Gasparriani thinks, that this process blocks the lymphatic channels in the optic nerve-sheath, and prevents the removal of effete matters which normally, to a slight degree, occurs through this channel. Hence the rise of tension and excavation—*i. e.*, the production of what has been called *posterior glaucoma*.

**Diagnosis.**—It is of the utmost importance that glaucoma should be recognized, if possible, in its very incipency. The most usual prodromal symptoms are a frequent desire to change the reading-glasses, periods of obscuration of vision, and the halos surrounding the lamp-lights.

The glaucomatous attack itself has frequently been mistaken for a "cold in the eye," for iritis,—when the disease has been aggravated by the instillation of atropin, which under almost

<sup>1</sup> A translation of the Dutch original of Snellen's article, "A Historical Essay on the Development of our Present Knowledge of Glaucoma," which has been quoted several times, is found in the *Ophthalmic Review*, Feb., 1891.



all circumstances is contraindicated,—for neuralgia, and for reflex ocular pain.

The condition of the pupil, the diminished depth of the anterior chamber, and the increased tension of the globe, are the symptoms which should prevent so fatal an error. As pointed out by Parisotti and Trousseau, *ophthalmic migraine* sometimes simulates glaucoma, inasmuch as it may be associated with increased intra-ocular tension, arterial pulsation in the fundus, and contraction of the visual field.

The differential diagnosis of simple chronic glaucoma and atrophy of the optic nerve has been referred to and presents considerable difficulty. The absence of constant increased tension in the simple form of the disease, or at least its doubtful presence, removes an important diagnostic point. Help may be obtained by observing the visual fields. In glaucoma the color-fields present a restriction corresponding with that of the form-fields, while in atrophy the peripheral color vision, especially for red and green, is markedly deficient. The value of the shape of the field and especially of the scotomas has been described (page 408).

Examination of the light-sense may be made. In glaucoma the "light minimum" is said to be deficient, but the "light difference" not far from normal; in pure optic atrophy there is imperfect ability to distinguish between different intensities of illumination ("light difference"). Practically, these examinations are difficult to make and the results are not always satisfactory.

It is an inexcusable error to confound the failing vision of chronic glaucoma with that of cataract, the greenish reflex of the lens, which may be seen in the pupillary space, being mistaken for an opacity of the lens. Eyes have been permitted to pass into blindness, and their possessors deluded with the hope that they were waiting for the ripening of a cataract which never existed. An ophthalmoscopic examination would settle the diagnosis at once.

**Prognosis.**—Glaucoma does not tend to spontaneous cure, but, if unchecked, to absolute blindness; hence the prognosis is unfavorable if proper treatment cannot be applied. Prog-

nosis also depends upon the type of the disease and the stage of its development. Other things being equal, uncomplicated acute cases furnish the most reasonable hope of complete cure, and if a technically correct operation can be performed *early*, the result is usually satisfactory. In chronic cases much depends upon the amount of degenerative change in the tissues, and the prognosis must be guided by the state of vision, the extent of the field, and the condition of the iris. The effect of treatment upon the progress of glaucoma is included in the following section :

**Treatment.**—In most of the cases of glaucoma some form of operation—by preference, in the opinion of the author, iridectomy—is needed to check the disease.

It may happen, however, that an operation is not at once possible, and hence the myotics are temporarily indicated. In the prodromal stage eserine should be employed and will usually relieve the symptoms. In acute cases the same drug, in a strength of from  $\frac{1}{2}$  to 2 grains to the ounce, acts favorably, provided the pupil will contract under its influence. It acts more efficiently when combined with cocaine. Pilocarpine in twice this strength may be substituted. Myotics act by drawing the iris away from the filtration angle, and, by contracting the pupil, cause widening of the spaces of Fontana and absorption of the fluid. A drop or two of the selected solution should be instilled every hour or two until relief is obtained; if this does not occur, the drug should be abandoned and an operation at once undertaken. Arecoline in 0.5 per cent. solution has also been used; with this drug the author has had no experience. Dionine in 5 per cent. solution has been advised, because it produces prolonged anesthesia and analgesia of the cornea. The author's experience with this drug is limited; it has not made a favorable impression.

In addition to the use of eserine during an acute attack, the temple may be leeches, warm fomentations applied, and rest and relief from pain secured by the exhibition of morphine and chloral, the latter drug having some influence in reducing tension, but full doses of salicylate of sodium act more favorably than any other constitutional remedy (Sutphen, Friedenwald);

indeed, they are most useful in any form of glaucoma associated with pain. Advantage may further be gained by giving a purge and a sedative fever mixture. Medicinal treatment is only a temporary matter and must not be relied upon.

In chronic inflammatory glaucoma eserine (the sulphate or salicylate) or one of its substitutes may be employed until it is decided what operation shall be done and when it shall be performed. In the chronic simple variety of the disease the indications for myotics are not so clear. The energetic use of eserine causes some irritation of the ciliary body and spasm of accommodation, and, as has been stated, strain upon the accommodation predisposes to glaucoma. Hence if eserine is to be used continuously, it is better not to employ it in a too strong solution (gr.  $\frac{1}{4}$ — $\frac{1}{8}$ — $\frac{1}{3}$  will suffice), and in the belief of some surgeons, pilocarpin is preferable. This congestion of the ciliary processes induced by eserine sometimes entirely defeats its proper action. Another point, although a minor one, is that its continuous use tends to cause a follicular conjunctivitis in some eyes. *Massage of the eyeball* has been recommended by several authors, and is said to have been followed by improvement in vision and deepening of the anterior chamber.

Iridectomy is the best method of treating acute glaucoma. It should be performed *early*, in the prodromal stage if possible, while the excretory apparatus is still intact and *before the root of the iris is welded to the cornea*. General anesthesia should be induced before its performance, because the high tension of the eyeball somewhat nullifies the action of cocaine. Much depends upon the exact position of the iridectomy, which is difficult of performance on account of the narrow anterior chamber, and no caution should be omitted which will secure perfect quiet on the part of the patient.

The following points must be observed: (1) About one-fifth of the iris should be excised, the detachment being made up to the periphery by cutting first one side of the portion of the iris which has been drawn out of the wound, then dragging it across to the other angle and completing the excision, thus removing everything up to the ciliary border. (2) The wound

should be sufficiently large to permit of such extensive detachment of the iris. (3) The point of selection for the entrance of the keratome should lie in the sclerotic coat, about 2 mm. from the apparent border of the cornea. (4) The knife should be withdrawn slowly in order to prevent a sudden gush of aqueous humor and a too rapid reduction of tension, which might be followed by intra-ocular hemorrhage. (5) Great care must be taken that no portion of the excised iris remains in the angles of the wound. (6) A preliminary scleral puncture, as has been advised by Priestley Smith and Gifford, is most useful, especially if the tension is exceedingly high and the anterior chamber very narrow.

A favorable result is indicated if the tension is lowered; an unfavorable one if this remains high. If there is a sudden rise of tension a short time after the operation, accompanied by severe pain, there is reason to suspect intra-ocular hemorrhage.

The cutting of the iris is often followed by an extensive hemorrhage into the anterior chamber. A prolonged effort to get rid of this blood should not be made lest the trituration produce cataract. The blood will absorb, although it may take many days and even weeks before this is entirely accomplished.

The reforming of the anterior chamber is sometimes delayed as long as a week. Occasionally, a day or two after the operation there is some slight rise of tension in the eye, which is of temporary character.

There is difference of opinion in regard to whether the eye should be bandaged or not, after operations of this character. The author believes that not only should a bandage be applied, for the first few days, to the eye upon which the operation has been done, but also to the fellow eye; and that the one placed upon the affected organ should remain there until complete restoration of the anterior chamber has taken place by healing of the wound. In most instances it is best to perform the iridectomy directly upward, so that the overhanging upper lid may cover the coloboma. It may be necessary, in the event of one iridectomy failing, to repeat the operation or else to

perform a sclerotomy. It is a wise precaution to instil eserin into the eye which has not been operated upon, during the course of the treatment, because it is well known, in acute glaucoma, that iridectomy may be followed by a speedy outbreak of the same disease in the opposite eye.

If this eye has a decidedly shallow anterior chamber, and if there is a history of prodromal glaucomatous phenomena, it should be submitted to operation as soon as the iridectomy wound in the opposite eye has firmly healed, certainly before the patient passes from skilled observation, because it is practically certain that it will be attacked like its fellow. If the signs of impending glaucoma are not clear and the eye is nevertheless suspected, the mydriatic test suggested by Edward Jackson, Harlan, and Brailey, which consists of the instillation of a solution of homatropin and noting whether it produces any rise in intra-ocular tension or pulsation of the vessels of the fundus, may be employed. Should the test be positive, it would seem proper to perform what Treacher Collins has called a *preventive iridectomy*. If both eyes are affected, both should be operated upon, if the conditions are suitable, at proper intervals; sometimes in acute cases operation on one eye must immediately be followed by operation on the other.

One of the complications which may follow the operation of iridectomy in glaucoma is the formation of a bulging scar at the seat of incision, sometimes called a *cystoid cicatrix*. This is especially true if due care has not been taken to free the angles of the wound from adherent iris. On the other hand, in severe cases, this very cystoid cicatrix, by permitting a filtering of the liquids, has been regarded as a favorable condition. To this view of a cystoid scar the author cannot subscribe.

The treatment of chronic inflammatory glaucoma and simple glaucoma by iridectomy is less likely to be followed by brilliant results than when it is employed in acute cases; and numbers of instances are on record in which, after the performance of an operation, entirely correct in its technic, the disease has not been stayed. Some surgeons doubt, for this

reason, the propriety of iridectomy in simple glaucoma and depend upon myotics locally and strychnin internally.

An operation should be done before much contraction of the field has occurred. Nettleship believes that the state of the pupil and its reaction to eserine furnish a good prognostic guide for operative interference in chronic glaucoma.

The conclusions of Gruening in regard to this matter are as follows: In chronic inflammatory glaucoma without degenerative change in the iris, a satisfactory result follows a careful iridectomy. If, however, there is degenerative change in the iris, iridectomy may not give the desired relief. In simple glaucoma iridectomy generally maintains the condition of vision which was present before the operation, other things being equal, and consequently is a proper surgical procedure.

Even if there is a good deal of contraction of the field, and the optic disc quite pale (provided the patient is not too far advanced in life), it is proper to attempt an operation, especially if both eyes are affected. Bull's advice, after all the chances of success and failure have been fairly stated, is "to operate in cases of chronic progressive glaucoma, and the earlier the better," and with this advice the author is in full accord. He agrees with de Wecker that the many disastrous results which have been credited to operative interference in this disease are largely due to a failure properly to distinguish optic nerve atrophy with excavation from chronic simple glaucoma and to an unreasonable delay in operating.

In a certain number of cases (Friedenwald has collected 24, 18 of them being women) a perfectly smooth iridectomy is followed by *malignant glaucoma*. The symptoms which usually appear one or two days after the iridectomy are: marked increase in tension, obliteration of the anterior chamber, fixation of the coloboma, ciliary tenderness, chemosis of the conjunctiva, swelling of the lids, and rapid loss of vision. Hence the importance of following Schweigger's advice to operate in chronic glaucoma affecting both eyes, first upon the worse one, even if it is blind. If no complication arises, in the majority of cases iridectomy on the fellow eye will be followed by a normal healing process. Some surgeons, however, for

example Nettleship, Knapp, and Gruening, proceed at once to operation on the better eye if the fellow eye is blind or nearly blind. The treatment of malignant glaucoma consists in the instillation of eserine, or posterior sclerotomy, and the administration of large doses of salicylate of sodium (Friedenwald).

The operation of *sclerotomy* has been used as a substitute for iridectomy, but the weight of testimony in favor of the latter operation is sufficiently great not to make it a more desirable mode of procedure than iridectomy except in selected cases. Every iridectomy which is peripherally situated, and in which the knife enters through the sclera some distance from the apparent border of the cornea, is in itself a sclerotomy. It is useful as a supplement to iridectomy if the tension is not reduced, and may be employed in old blind glaucomatous eyes to relieve pain. According to de Wecker, sclerotomy, followed later by iridectomy, which can then be performed more correctly owing to the improved state of the eye, is preferable to a primary iridectomy.

It is not entirely certain how iridectomy cures glaucoma. It has been suggested that this is accomplished by the removal of the portion of tissue which closes the angle at the anterior chamber; by the moderation of the blood pressure in the iris (Exner); or by the filtration of the fluids of the eye, through the line of healing, which, for this reason, has been called the *filtration scar*. The details of performing iridectomy and sclerotomy will be described in the chapter devoted to operations.

Abadie, believing that the symptoms of glaucoma can be explained by an excitation, sometimes transitory and sometimes persistent, of the vasodilator fibers of the ocular blood-vessels, suggested in 1898 that relief from this disease might be obtained by section of the sympathetic in the neck, and soon afterward the first operation of resection of the cervical sympathetic was performed by Jonnesco. Since that time the operation of *sympathectomy*, or excision of the superior cervical ganglion of the sympathetic, has been performed a number of times. Certainly the operation should not replace iridectomy or sclerotomy and should never be used in acute

cases (Axenfeld), but it may be employed for the relief of cases of glaucoma after other therapeutic measures have failed, and is worth serious consideration in hemorrhagic glaucoma and in certain cases of advanced glaucoma with extremely poor vision, and a condition of the ocular tissues which would render it almost certain that iridectomy would be followed by disastrous results. Melville Black has suggested that not only the superior, but also the middle ganglion, should be excised.

For the relief of the pain of absolute glaucoma *opticociliary neurotomy* has been performed, and is still advocated by some surgeons. In the opinion of the author enucleation, or one of its substitutes, is a better operation. Under these circumstances, if the other eye shows any prodromal signs of glaucoma, it would seem proper that an iridectomy should be performed in anticipation of the glaucomatous attack.

**Secondary glaucoma**, or that form which arises in consequence of some preexisting disease of the eye, may, like the primary variety, assume an acute or chronic type.

It may follow inflammation of the iris and ciliary body with the production of extensive synechiæ; ulcers of the cornea which have perforated and produced considerable anterior synechiæ or staphylomatous bulging; swelling of the crystalline lens, after discission; dislocation of the lens; detachment of the retina, associated with severe hemorrhage; the growth of a choroidal sarcoma or other intra-ocular tumor; and choroïdoretinitis or disease of the retinal vessels.

In most of the instances mentioned there is no difficulty in diagnosing secondary glaucoma by the history of the case and the knowledge of the preexisting disease. This is not so easy if the original trouble has been deep in the eye, like a sarcoma. In these cases the glaucoma is usually absolute.

**Treatment.**—Secondary glaucoma in general terms requires the same treatment as the primary form of the disease. A dislocated lens, or a lens swollen after discission for cataract, should be removed. Absolute glaucoma associated with great pain, and if there is any suspicion of intra-ocular growth, indicates excision of the globe.



**Hemorrhagic glaucoma** is one type of secondary glaucoma in which numerous retinal hemorrhages appear as the result of thrombosis of the retinal vessels, or hyaline degeneration of their walls, or other causes likely to produce extravasation of blood (albuminuric retinitis). The tension rises and the character of the disease may be acute, subacute, or chronic. This condition should be sharply differentiated from primary glaucoma associated with retinal hemorrhages, although sometimes it is exceedingly difficult to decide whether the glaucoma is secondary to the hemorrhages, or whether the hemorrhages have been produced by alterations in the tension of a glaucomatous eye. With the ophthalmoscope one may see the ordinary appearances of glaucoma and numerous retinal hemorrhages; or, in addition, there may be the lesions of the disease which has caused the hemorrhages and the glaucoma which followed them. Hemorrhage into the vitreous may occur, obliterating the fundus reflex, and then the cornea is steamy, the anterior chamber obliterated, the iris discolored, and the eyeball intensely injected and very hard.

Iridectomy is not usually followed by good results in hemorrhagic glaucoma. It may lead to permanent blindness by fresh hemorrhagic exacerbations. If attempted it should be preceded by posterior sclerotomy. The results of anterior sclerotomy are more favorable than those of simple iridectomy. Tapping the vitreous alone may be followed by relief. Sympathectomy has been suggested. If the pain becomes intense and blindness ensues, enucleation is required. General treatment is of importance, as the patients are usually the subjects of general vascular disease: ergot, the cautious use of cardiac sedatives, and strict regulation of the diet and mode of life. Locally, measures to relieve ocular congestion and the myotics may be employed.

**Complicated Glaucoma.**—Two kinds of complicated glaucoma are described which may be looked upon as varieties of the secondary form of the disease, namely, *cataract with glaucoma*, and *high myopia with glaucoma*. In the former condition one eye alone is usually affected. It is to be

distinguished from the lenticular opacity produced by absolute glaucoma. During the formation of cataract glaucoma may occur, due probably to swelling of the lens and lessening of the circumlental space.

In high myopia with glaucoma, the usual changes in the field of vision and the papilla are present. In addition to this there is more or less choroidal disturbance, which may itself be the cause of the glaucomatous condition.

*Hydrophthalmos*, or that disease of the eye which has been looked upon as a congenital glaucoma, has been described on page 321.

## CHAPTER XIII.

### DISEASES OF THE CRYSTALLINE LENS.

**Congenital Anomalies.**—In addition to congenital cataract and congenital displacement of the lens, which are described on pages 439 and 450, two anomalies require mention.

1. **Coloboma of the Lens.**—This defect occurs usually with a similar defect in the iris and choroid. The normal, rounded margin of the lens is replaced by a straight margin in a horizontal direction or incurved. The amount of the defect varies from a slight indentation to about one-quarter of the lens-substance. It is always situated in the inferior half of the lens (Heyl).

2. **Lenticonus.**—This is an abnormal curvature of the posterior surface of the lens or an anomaly of the nucleus (L. Müller), either unilateral and associated with lenticular opacities, or without such association, and then usually bilateral. Anterior lenticonus also occurs. With the plane mirror a sharp red disc, surrounded by dark shadows, like an oil-globule in water, may be seen (Knapp).

**Cataract.**—Under the term *cataract* are included several types of an opaque condition of the crystalline lens, of its capsule, or of both these structures, which anatomically are distinguished by the titles *lenticular*, *capsular*, and *capsulolenticular*.

**Varieties of Cataract.**—(1) *Primary*; (2) *secondary* to disorders in other portions of the eye; (3) *symptomatic* of a general malady or local injury.

A cataract is either *partial* and stationary, or progressive and becomes *complete*, and clinically is classified as *senile*, subdivided into *nuclear* and *cortical*; *congenital* or *juvenile*, subdivided into *complete* or *partial*; *secondary*, or *complicated*; *traumatic*; and *after-cataract*.

Cataracts are also classified according to their consistence as *hard*, *soft*, or *fluid*, and sometimes are designated by their color as *black*, *white*, *amber*, etc. Although in many instances the precise division of cataract into special varieties may be unimportant, the following table, compiled from the classifications employed in various standard works, may be useful to the student as a résumé of what has gone before :

Anatomically	{			1. Lenticular.
	{			2. Capsular.
	{			3. Capsulolenticular.
Clinically	{	1. Senile	{ (a) cortical (b) nuclear }	general.
		2. Juvenile or congenital	{ (a) complete (b) partial }	{ complete. congenital. lamellar, or zonular. pyramidal, or polar.
	{	3. Complicated or secondary	{ anterior polar cataract. posterior polar cataract. complete cataract.	
		4. Traumatic.		
		5. After-cataract.		

**Symptoms.**—The following symptoms are present with more or less constancy in cataract, exemplified by the senile form of this disease.

1. *Change in Visual Acuity.*—The amount of depreciation of sight depends upon the situation and extent of the opacity, and sometimes upon alterations in the refractive power of the lens. Thus there may be an increased refraction at the nucleus, causing myopia, often called *prodromal myopia*. Under these circumstances distant vision is improved by concave lenses and reading becomes possible without the aid of convex glasses. This is the so-called "second sight," which in itself is strong presumptive evidence of the existence of cataract. In like manner the change in the lens may produce an irregular astigmatism, or an astigmatism "against the rule" may be developed.

2. *Hyperemia of the Conjunctiva.*—This is caused by the strain which the effort to see through a somewhat clouded lens produces.

3. *Pain and Photophobia*.—These symptoms are not prominent; but sometimes, owing to the condition of disturbed choroid which commonly is associated with cataract, patients complain of dull, aching pain or other asthenopic symptoms. Tinted glasses relieve the photophobia and permit slight dilatation of the pupil, which sometimes improves vision if the opacity is central.

4. *Polyopia and monocular diplopia* are occasionally the result of incipient cataract, and are due to the irregular astigmatism which the alterations in the lens have produced.

5. *The Anterior Chamber*.—This may be normal in depth—the usual condition; shallower than normal—indicating a swollen lens; or abnormally deep—a symptom of a small lens.

6. *The Pupil*.—This may be natural in appearance and the mobility of the iris entirely normal; but sometimes the effect of exclusion of light or of a mydriatic fails to induce a dilatation of the pupil.

We speak of the “color of the pupil,” and this varies in cataract according to the degree of maturity and the hue of the opacity. Hence in the unilluminated pupil no change is seen in its color in incipient cataract; but in a ripe cataract the pupillary space may appear dull, gray, and even white, according to circumstances. In examples of so-called “black cataract” the pupil is dark. The mere inspection of the pupil, however, without optical aid, is not sufficient to ascertain the condition of the lens, which continues to increase in size even with advancing years, if it remains clear (Priestley Smith). But it becomes firmer, straw-colored, and reflects more light. This creates a dull sheen in the pupil which may be mistaken for cataract.

**Diagnosis.**—From what has been said, it is apparent that the absolute diagnosis of cataract depends upon the use of the ophthalmoscope. Since the introduction of the ophthalmoscope, the *catoptric test* has fallen into disuse, although it may be employed to determine the presence of the lens and in the diagnosis of black cataract.

This test is performed as follows: If, in a dark room, a lighted candle be moved before a healthy eye with dilated

pupil, three images of the flame will be seen: two erect, formed by reflection from the convex cornea and anterior surface of the lens, the former producing the bright image and the latter the more diffuse; and one inverted, relatively clearer, from the posterior surface of the lens. If, now, the lens be opaque, the inverted image will be wanting, the deeper erect image also disappearing when the opacity involves the capsule, the corneal image being then alone visible.

Before using the ophthalmoscope for the detection of cataract the pupil should be dilated, preferably with homatropin, cocain, or euphthalmin. The examiner then proceeds in the manner described on page 112, and will detect in incipient cataract spots or streaks of opacity, often radiating from the periphery toward the center, which appear black from the interference with the reflection of light from the choroid. In like manner the nucleus may be seen to be hazy and the periphery clear, or the sectors of the lens are strongly marked. The beginning of cataract is also made evident by flaws in the lens, which have been compared to cracks in glass, and are known as "striæ of refraction." If the entire lens is opaque, no portion of the pupillary space exhibits any red reflex from the fundus, although a lens which appears completely cataractous through the undilated pupil may exhibit spots of incomplete opacification in the periphery recognized by the transmitted red glare when the pupil is dilated. The final examination with transmitted light should be made with a + 16 D lens.

With *oblique illumination* (page 60) the opacities, if incipient, appear as white or gray streaks and dots.

When a progressive senile cataract is fully matured, its presence may often be detected without any special examination, except in the instances already mentioned, but it is a matter of the utmost importance to ascertain when this full maturity has been reached, or, in other words, whether the cataract is "*ripe*." This is determined in the following manner:

The patient being placed in the proper position, the pupillary space is illuminated. If the opacity is complete, the opaque lens, covered by its capsule, is level with the margin of the pupil,

and there is no shadow; if not, the major portion of the opacity is at a level posterior to the plane of the pupil, or in other words, a clear or partly clear space is present between the iris and the opaque portion, and a dark semicircle appears upon the opacity at the side from which the light comes. This is the shadow of the iris. Shining sectors or the transmission of a red glare indicate immaturity, even if the shadow is absent. In hypermature cataract the shadow is visible, but the surface of the lens is flat.

**Development, Course, and Pathology of Cataract.**—In progressive *senile*, or as it is sometimes called, *simple* cataract, there is a period of growth from incipency to full maturity

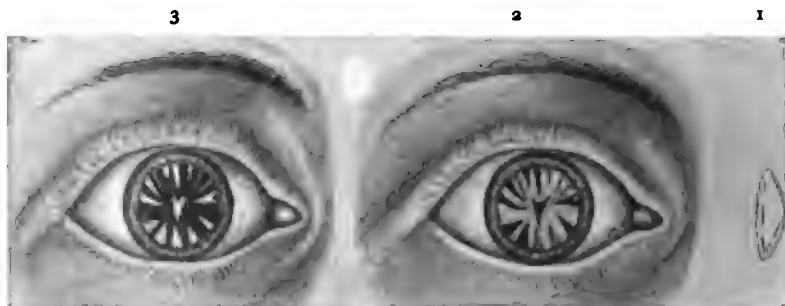


FIG. 142.—Cortical cataract: 1, Section of lens, opacities beneath the capsule; 2, opacities seen by transmitted light (ophthalmoscope mirror); 3, opacities seen by reflected light (oblique illumination) (modified from Nettleship).

which varies considerably, and consumes from one to three years or longer.

Immature cataract, especially of the cortical variety, may remain unchanged for many years. At other times the development of the disease is comparatively rapid. This slow progress of cortical senile cataract should be remembered, and the discovery of *striæ* in the lens need not condemn the patient to rapid deterioration of vision. Indeed, certain lenticular opacities are practically stationary for years.

The opacities begin either *equatorially*—*i. e.*, at the edge of the lens—or *centrally*—*i. e.*, at the nucleus. In the former case the *striæ* begin just beneath the capsule and are seen both in the anterior and posterior portions. They gradually

radiate toward the center (encroach on the pupil space), the nucleus becomes hazy and sclerosed, the cortical layers become opaque, and finally the cataract is complete.

The participation of the nucleus and the cortex is sometimes spoken of as *mixed cataract*.

In the second variety the nucleus becomes hazy and the surrounding cloudiness always remains the most opaque portion of the cataract, which gradually spreads to the cortex (Fig. 143).

According to Schoen, senile cataract invariably begins as equatorial cataract, with fine white dots and streaks, while the nuclear sclerosis never appears without equatorial cataract,

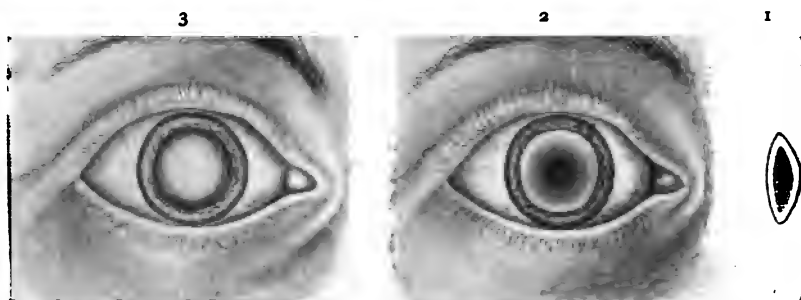


FIG. 143.—Nuclear cataract: 1, Section of lens, central position of opacity; 2, appearance by transmitted light; 3, appearance by oblique illumination (modified from Nettleship).

being secondary to it, the association occurring first after the sixtieth year.

Cataract may also begin as a more or less diffuse clouding, or in the form of small dots, scattered through the cortex, or in opacities which, with transmitted light, resemble dark flocculent precipitates. Under the last circumstances the advance is more rapid than when striæ are the first manifestation (Swanzy). Instead of going on to maturity, a nuclear haze or a spear of opacity may remain stationary, or at least show no practical change for years.

During the formation of cataract the following changes occur in the lens: First, there is a separation of the lens-fibers with a collection of fluid between them, which coagulates into



drops—the spheres of Morgagni. Later there are swelling, clouding, and fatty degeneration of the cortical fibers and the formation in them of nucleated vesicular bodies. Ultimately there is disorganization of the fibers, and the lenticular tissue is changed into fat-drops, spheres of Morgagni, and albuminous liquid, and the cortex separates from the capsule, the liquor Morgagni collecting between them. The lens nucleus becomes sclerosed, but in other respects is not greatly altered.

Maturity may be succeeded by the stage of “overripeness” and the cataract gradually shrinks to a flat disc, or the liquefaction of the cortical matter permits displacement of the nucleus, a type which is known as *Morgagnian cataract*. Tremulousness of the iris is seen in overripe cataracts. Sometimes calcareous degeneration in the lens or its capsule may take place.

The cataract, the development of which has just been described, is for the most part “hard”—*i. e.*, the nucleus of the lens is large. Under the age of thirty-five all cataracts are “soft”—*i. e.*, the nuclei are small or wanting, just as the lenses in which they develop have failed to attain the density which later they assume.

**Causes of Cataract.**—1. *Age of Life.*—Cataract which becomes complete is especially frequent after fifty years; but, as Fuchs remarks, it cannot be regarded as a physiologic attribute of old age. It is a pathologic process, and age, while it is an important factor in its development, must often be regarded only as a predisposing cause. Occasionally total cataract without apparent constitutional disease is found in adolescents. The very beginnings of cataract, according to one observer, are not peculiar to old age, but appear between the twentieth and the thirtieth year as an equatorial cataract.

2. *Sex.*—This appears to have no decided influence, the sexes being about equally affected, unless it be in the zonular variety, in which the greater liability of females has been recorded.

3. *Disease.*—Sugar has been found in the urine of about 1 per cent. of cataract cases, and the cataractous lenses of pa-

tients the subjects of diabetes mellitus at times contain sugar. An examination of the urine should always be made in cataract cases, especially when developed in young subjects, and sugar carefully sought for. According to Klein, posterior polar, combined with posterior cortical, cataract, unassociated with choroiditis, is significant of diabetes. Albumin is present in about 6 per cent. of the cases, but the etiologic relation of nephritis to cataract has not been proved.

Cataract has also been noted in connection with idiopathic fevers and allied diseases, with gout, malaria, influenza, rachitis, syphilis (Bos), angiosclerosis, and especially atheroma of the carotid (Michel), epilepsy, and other convulsive seizures, meningitis (Bock), certain cutaneous affections (Mooren, Rothmund), and with bronchocele. As Becker has stated, however, a connecting link between constitutional maladies and opacities of the crystalline lens has not been established. It is possible that sclerotic changes in the nutrient vessels of the anterior uveal tract may aid in the development of lenticular degeneration.

4. *Occupation*.—Cataract is especially frequent among glass-blowers, and is attributed to the effect of the radiated heat and excessive perspiration. It is not improbable that investigations would show the same liability in puddlers and others exposed to intense heat.

5. *Heredity*.—Remarkable examples of the influence of heredity in the formation of cataract have been published. It has been noted that the tendency is more marked in the child-bearing period, and that the transmission is through the female line; transmission through the male line only, however, has been recorded.

6. *Toxic Agents*.—Cataract has been produced artificially by poisoning rabbits with naphthalin (*naphthalin cataract*). In addition to the cataract, there are changes in the retina and vitreous and also general disturbances.

During epidemics of *ergotism* patients are at times affected with cataract (*raphanic cataract*), the appearance having been noted almost exclusively in the convulsive type of this toxemia; hence it is not certain whether the lenticular opacity

results from the poisoning by the ergot or on account of the convulsions.

7. *Traumatism*.—This may produce cataract by a *direct* injury to the lens, or in an *indirect* method—for example, by a concussion (*concussion cataract*). To this category belong those cataracts which have followed a lightning-stroke. A number of examples are recorded, both double and single, partial and complete. In addition to the cataract, optic neuritis, optic atrophy, rupture of the choroid, iritis, iridocyclitis, myosis, mydriasis, and palsy of accommodation have been observed.

8. *Diseases of the Eye*.—Cataract may be secondary to numerous acute and chronic affections of the eye—viz., iritis, iridocyclitis, iridochoroiditis, choroiditis, detachment of the retina, glaucoma, and diseases of the cornea, especially sloughing ulcers. The frequent coexistence of disturbance of the choroidal coat and incipient cataract has led to the opinion that while opacity of the lens (so-called senile) is a condition commonly seen in advanced life, it does not, in all probability, depend upon senile changes, but is originated in local pathologic states involving the nutrition of the eye itself (Risley).

9. *Accommodative Strain*.—Investigations show that a large majority of cataractous eyes are hyperopic and astigmatic, and that the danger of cataract is said to be increased when the astigmatism is against the rule and remains uncorrected. The evident prophylactic measure is the use of proper glasses.

The etiology of cataract is by no means always clear, and often several factors are necessary to explain it; sometimes no direct cause can be assigned; frequently there are extra-ocular causes and the cataract results from nutritive disturbances.

The following additional facts in regard to the clinical varieties deserve attention:

I. *Senile Cataract* (*Simple Cataract*; *Gray Cataract*).—This, representing the type of general cataract, is nuclear, cortical, or mixed in its origin, and is rare before the forty-fifth year. It may not appear before the sixtieth year. Its course from incipency to full maturity has been described.

The color usually is gray, and the nucleus, which itself does

not become cataractous, but is hardened, may be recognized by its yellowish or brownish hue and its waxy appearance.

If the nucleus is small and the surrounding cortex uniformly white, the cataract is comparatively *soft*; if the nucleus is large and the color of the cataract distinctly gray, or yellowish or brownish, it is *hard*.

Instead of a gray or grayish-white color, the cataract may be yellow or amber, or the sclerosis of the nucleus extends to the cortical substance so that the whole lens is brownish and the pupil black (*black cataract*). Sometimes there is opacity of the hyaloid membrane, which Fink calls *hyaloid cataract*. Occasionally *cholesterin crystals* may be found in cataracts, not only in the senile, but also in the juvenile variety.

Senile cataract generally is bilateral, one eye being more affected than its fellow; but a ripe cataract may occur upon one side only, the other lens being not at all or only slightly affected.

**II. Juvenile or congenital cataract** appears in the form of a complete or partial opacity of the lens, and is comparatively a rare affection.<sup>1</sup>

In the complete form the lens usually is white or bluish-white in color, densely opaque, and *soft*. The eye may be otherwise healthy, or there may be changes in the choroid, retina, optic nerve (congenital amblyopia), and sometimes vices of conformation, as coloboma, microphthalmos, and hydrophthalmos. Disturbances of nutrition during intra-uterine life, changes in the choroid, arrest of development, and heredity, have been invoked to explain its existence.

In forms of cataract developed in early life the evidence of the influence of heredity is often strong; more usually this is lacking in the congenital types.

General cataracts in young people (*complete cataract of young people*) may arise without known cause. These are bluish-white, often have a sheen like pearl, and are soft.

*Diabetic cataract* is also complete, and may be soft or hard, according to the age at which it develops.

<sup>1</sup> In the tables of de Wecker, among 40,000 cases of various forms of eye disease, 36 total congenital cataracts are enumerated.

There are several varieties of *partial* congenital cataract:

(a) *Zonular* or *lamellar cataract* appears, as its name implies, in the form of an opaque layer surrounding the clear, but sometimes cloudy, center of the lens, and is the most frequent form of partial congenital cataract. Usually it is double, but may be unilateral, and is either congenital or forms in early infancy. The cataract is stationary in most instances, but occasionally becomes complete.

If the center of the pupil is examined, a reddish point surrounded by a grayish halo will be observed. When the pupil is dilated with atropin and examined with the ophthalmoscopic mirror, the central dark zone will be apparent, surrounded by a reddish circle, due to the reflection from the fundus passing

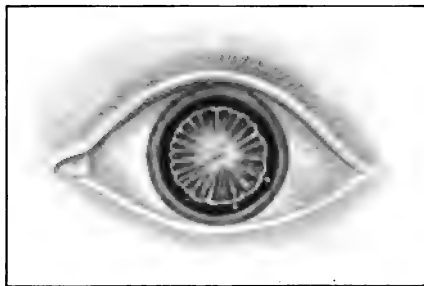


FIG. 144.—Zonular cataract (after Spicer).

through the peripheral part of the lens, which remains clear. With oblique light the appearances may be as in Fig. 144. A rare type is several zones of opacity separated by zones of transparency. Patients with zonular cataract act like myopes, and the refraction of the eye may be myopic. Macular changes are not infrequent.

The cause of lamellar cataract is not certainly known. In the congenital variety it is probably due to some developmental defect; in the variety arising in early infancy some fault in nutrition has occurred. Most often the subjects are rachitic, and present the teeth and cranial asymmetry peculiar to this affection. A history of convulsions is common, and the dental defects, which are present in the form of lines, furrows, or terraces running transversely across the incisors or canines, are

considered by Hutchinson to be due to the mercury which in all probability was given for the convulsions which caused the cataract. Anatomically, lamellar cataract consists of a narrow zone of degenerative change in the lens-fibers, situated between the nuclear and cortical areas (Lawford).

(b) *Central cataract (central lental cataract)* consists of a white opacity in the central part of the lens, due probably to faulty development at an early stage of intra-uterine existence. Sometimes vision is surprisingly good; at other times it may be poor, and defects of development in the eye may be present and nystagmus may develop.

(c) *Pyramidal Cataract.*—This is also known as *anterior capsular* or *polar cataract*, and consists of a small, well-defined, pyramidal-shaped or circular opacity due to hyperplasia of the

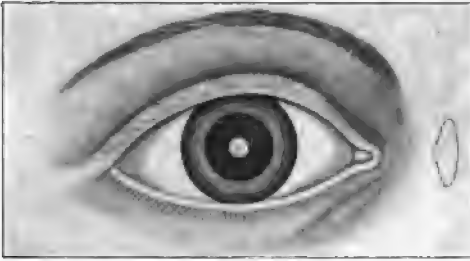


FIG. 145.—Anterior polar cataract (after Nettleship).

capsular epithelium and degeneration of the lens-fibers in that position. It probably arises in consequence of contact of the lens and cornea in fetal life, which causes an arrest of osmose of nutritional fluid (E. T. Collins). Mules suggests that these cataracts may be cretified remains of the pupillary membrane.

At the posterior pole of the lens an opacity similar to the one described may be found, known as a *posterior polar or pyramidal congenital cataract*. It is caused by vestigial remains of the hyaloid artery at its lenticular attachment. These opacities are sometimes separated into those which lie beneath the capsule and those which exist upon its surface. A small dot-like opacity of this origin, and which does not disturb vision, is quite common.

(d) *Punctate cataract* is an unusual form of congenital len-

ticular change in which the opacities present themselves in the form of more or less fine points, occupying the center of the pupillary space. The cataract remains stationary for a long time.

(e) *Fusiform cataract* is a rare variety characterized by an opaque stripe passing from the anterior to the posterior pole of the lens. It may be combined with zonular cataract.

**III. Complicated or Secondary Cataract.**—This may be *complete* and arise in consequence of the various diseases of the eye enumerated on page 438. Calcareous changes are often seen in such cataracts. It may also be *incomplete*, and then is classified in the following varieties:

(a) *Anterior Polar Cataract.*—In addition to the congenital



FIG. 146.—Posterior polar cataract seen by transmitted light (from a case of pigmentary degeneration of the retina).

variety of this opacity there is an acquired type, which arises in consequence of a perforating ulcer of the cornea—for example, in ophthalmia neonatorum (see page 232). In infants' eyes it may follow ulceration of the cornea without perforation.

(b) *Posterior polar cataract*, as a congenital variety, has been described; but another form is the more or less star-shaped opacity sometimes seen at the posterior pole of the lens in high myopia, vitreous disease, disseminated choroiditis, and pigmentary degeneration of the retina. It may remain stationary for a long time, disturbing vision in proportion to its density, or it may progress and become complete.

**IV. Traumatic Cataract.**—This occurs by *direct* injury to the

lens by some penetrating substance which lacerates the capsule and then permits the entrance of the aqueous humor. The lens-substance swells up, becomes opaque, and some of it may escape into the anterior chamber. Absorption takes place in about six weeks. This course represents the most favorable outcome of such an accident. In other cases there may be iritis, cyclitis, and secondary glaucoma, owing to the swelling of the lens.

Instead of going on to complete opacity, an injured lens, in some instances, presents a limited opacity, which remains stationary; in other instances this disappears, and in still others there is slow advance of the opacity.

The opacity is explained by the action of the sodium chlorid of the aqueous humor upon the globulin of the lens-substance.

A more *indirect* mechanism of traumatic cataract is *concussion* (*concussion cataract*)—a blow upon the eye causing a slight rupture of the anterior or posterior capsule, followed by opacity, which may become general or retain a limited size for a long time. According to Nettleship, absorption of a complete concussion cataract is more uncommon than when the lenticular opacity has followed a direct trauma, although the lens may gradually shrink in size.

**V. After-cataract.**—This name has been applied to those changes which occur in the capsule of the lens remaining after the extraction of cataract. It is usually called *secondary cataract*.

These changes are either closure of the opening made in the capsule, opacity of the capsule itself from proliferation of its cells, or increased thickening in the capsule which may have existed before the lens was removed. The name has also been given to deposits of lymph, plastic exudate, and occlusion of the pupil which have followed unsuccessful cataract operations.

**VI. Capsular Cataract.**—The name *capsular cataract* is applied to thickenings and proliferations of the capsular epithelium which may be congenital, may follow inflammatory pro-



cesses of the eye (corneal ulcer), and may occur in connection with other degenerations in overripe cataract.

**VII. Capsulolenticular cataract** is the name applied to opacity of the lens associated with thickening of the surrounding capsule, most commonly in the center of its anterior portion.

**Prognosis.**—Incipient cataract in the form of striæ in the anterior cortex need not doom the patient to rapid deterioration of sight, because the existing vision is often maintained for long periods of time. *Spontaneous disappearance of senile cataract* has been reported. According to Pyle, this may occur on account of ruptured capsule, dislocation, or degenerative changes; rarely the phenomenon has been observed when the history of such etiologic relationship could not be obtained.

Operation is generally deferred until the cataract is “ripe,” but even then it must be ascertained whether the eye itself is in a healthy condition by attention to the following considerations:

(a) *The probable condition of the interior of the eye*, if no data of ophthalmoscopic examinations during the incipency of the cataract are at hand. This is ascertained as follows:

Place the patient before a lighted candle about 4 meters distant—the flame should be distinctly recognized. This gives evidence that the macular region is free from coarse disease. Now cause the eye under examination to fix the flame attentively, and move a second lighted candle radially through the field of vision. The flame should be recognized as soon as the rays strike the edge of the cornea, and the patient should be able to indicate the direction in which it is coming. Thus the “light-field,” or the “projection of light,” is tested, and, if the answers have been accurate, “projection of light is good in all parts of the field.”

If the patient fails to appreciate the candle-flame in any portion of the field, coarse changes may be suspected—*e. g.*, extensive choroiditis, detachment of the retina, glaucoma, etc.; but it is difficult or impossible to detect a small area of central choroiditis by this means (see also page 388). Fluid vitreous, indicated by tremulousness of the iris, is an unfavorable sign.

Should there be no light-perception, the case is an unsuitable one for operation.

(b) *The Probable Condition of the Refraction.*—It may be impossible to ascertain this unless some record is at hand of an examination when the media were still clear. Some idea of the refraction is obtainable by examining the glasses which the patient may have used during his reading days. High myopia renders the prognosis less favorable; indeed, the vision after operation in myopic cases, other things being equal, is not so good as that in hyperopes.

(c) *The Mobility of the Iris; its Reaction to a Mydriatic.*—This should be prompt and normal. Failure of iris reaction in either case may indicate imperfect conductive power in the optic nerve, or atrophy or other change in the iris.

(d) *The Age and General Condition of the Patient.*—Advanced age alone does not militate, as much as it would seem likely to do, against successful cataract extraction. So, too, the extraction of diabetic cataract is often followed by good results; and even the presence of chronic Bright's disease, while a complicating circumstance, does not forbid the operation. Great feebleness, dementia likely to become worse with confinement, nasopharyngitis, and chronic bronchitis are unfavorable conditions. According to Hansell, syphilis should be regarded as a dangerous complication.

(e) *The Condition of the Area of Future Operation and of its Surroundings.*—Disease of the lacrimonasal channels, trachoma, chronic conjunctivitis, or blepharitis contraindicates cataract extraction, because the wound is almost certain to become infected by the unhealthy discharges. Under such circumstances a line of treatment later described must be instituted before operation. A matter of importance, not always attended to, is the state of the rhinopharynx. This should be reasonably healthy to secure the highest type of success.

(f) *The Type and Condition of the Cataract.*—In making a prognosis the size of the nucleus and its position, the probable consistence of the cortex, the primary or secondary nature of the cataract, and its stage of maturity must be con-

sidered. Certain conditions (amblyopia) influence the prognosis in complete congenital cataract, and in the partial varieties, like the lamellar form, the eye may be defective in construction. In traumatic cataract the extent of injury to parts other than the lens must be regarded.

**Treatment.**—This may be divided into the treatment of *immature* and of *mature* cataract.

Drugs do not exist which can dissolve a growing cataract; and the use of electricity, which has been recommended, is of no value. Massage of the eyeball associated with the instillation of a mixture of glycerin and boric acid solution has been commended (Kalish). The author has failed to observe the slightest benefit from such treatment. In cases of traumatism of the lens, when the processes of absorption have already begun, they may be stimulated by the massage movements. None the less much comfort can be given to a patient with incipient cataract by attending to the following directions:

1. The refraction should be carefully tested and that glass ordered which gives the most accurate vision. It may be necessary to make frequent changes in the correcting lenses, to conform with the alterations in refraction brought about by the swelling of the lens.

2. Congestion of the choroidal coat may be relieved by the exhibition of certain alteratives, among which the iodids of sodium and potassium are the most suitable. These may be combined with small doses of bromid of potassium or bromid of sodium. Tonic doses of strychnin or tincture of nux vomica likewise serve a useful purpose. If by these means the asthenopic symptoms are relieved, the moderate use of the eyes may be permitted without danger of hastening the process of maturation. If the patient suffers from diabetes, nephritis, lithemia, or arteriosclerosis, suitable dietetic and medicinal measures should be employed.

3. Often comfort may be given and vision improved by keeping the pupil dilated with a weak mydriatic (if the opacity is central). Tinted lenses giving the best visual acuity should be worn. In other cases a myotic is useful.

If the vision of eyes suffering from cataract of the nuclear type is improved by mydriasis, this has been given as an indication for *optical iridectomy*, but it is not a sufficient one unless the patient finds by observation that the increased visual acuity, as noted by test-type examination, is also advantageous in pursuing his ordinary occupation.

**Artificial Ripening.**—The exceeding slowness with which a senile cataract may progress often leaves the patient in a state of semiblindness. To remedy this, several methods have been proposed for hastening the process of ripening:

Simple division of the anterior capsule; division combined with iridectomy (Mooren); division and external massage (Rohmer); iridectomy and trituration of the lens-fibers by rubbing the cornea over the coloboma with a horn spoon (Förster's method); paracentesis of the cornea, and internal massage directly on the anterior capsule with a small spatula (Sasso and Ricaldi and B. Bettmann, of Chicago); and simple paracentesis of the cornea with external massage (T. R. Pooley, of New York, and J. A. White, of Richmond, an operation practised by the latter surgeon with much success).

A dissection, after the manner of Graefe, carried deep into the lens-substance, is recommended by some surgeons (Schweigger) as the only satisfactory method, especially before the fortieth year.

**Treatment of Immature Cataract.**—Some operators of extensive experience (Schweigger) hold that the usual criteria of ripeness are erroneous in that period when accommodation is annulled by physiologic changes in the lens—that is, about the sixtieth year—and the lens may be extracted safely even if it is in part unclouded. It may also be done successfully at an earlier age.

Finally, certain operators (McKeown, Wickerkiewicz, Panas, Lippincott) perform extraction of immature cataract by the help of a syringe with which the tenacious cortical material is washed out by the injection of warm sterile water or physiologic salt solution.

If the unripe material is not removed, it may swell up and cause iritis. Therefore the safest plan is to wait for maturity;

but if this is impossible or very undesirable, the author has been in the habit of extracting an unripe cataract in preference to performing a ripening operation. This formerly was also the practice of Knapp; but recently he has ripened immature cataracts in a certain number of cases by the method of internal trituration, as employed by Born, Bettmann, and others, and has been satisfied with his results.

**Treatment of Mature and Complete Cataract.**—*Mature* cataract requires an operation for its removal, differing according to the age of the patient and the consistency of the cataract.

Hard cataracts, or those which occur after the fortieth year, are suitably removed either by—(a) simple extraction (extraction without iridectomy) or (b) combined extraction (extraction with iridectomy).

Soft cataracts, or those which occur before the thirty-fifth year, are suitably removed by—(a) linear extraction; (b) the needle operation, or that of solution by discission; and (c) the suction method. A soft cataract before the twenty-fifth year may be removed through a linear incision into the cornea, and a semifluid one by suction. Complete cataract of young people and complete congenital cataract are generally removed by discission, the latter variety of cataract being ready for operation after the completion of dentition.

**Treatment of Partial Congenital Cataracts.**—Central, lental, and zonular cataracts are treated by iridectomy or by discission. The former procedure is better if, after dilatation with a mydriatic, there is sufficient improvement in vision to justify the manufacture of a new pupil or glasses do not improve vision. This should be made opposite to the clearest part of the lens. If this does not prove satisfactory, the lens may be needled, or, finally, the entire lens may be extracted.

Pyramidal, punctate, and fusiform cataracts are not generally amenable to operative treatment. Discission is the method of operating applied to after-cataracts.

Extraction of *monocular cataract* will not give the patient increased visual acuity, because, owing to the inequality of refraction, the eyes will not work together. The operation

may be performed (simple extraction) for cosmetic reasons, to avoid overmaturity in the opaque lens, and to improve the field of vision upon the affected side. If there is divergence, a subsequent advancement of the internus may be necessary.

The technic of performing the various methods of cataract extraction, the dangers and accidents, will be described on pages 699-721.

After a successful extraction or solution, and after sufficient time has elapsed to secure firm healing, a suitable pair of lenses should be adjusted—one for distant vision and one for reading.

Removal of the crystalline lens produces the condition technically spoken of as *aphakia*, and causes a high degree of hyperopia, in the emmetropic eye corresponding to about 11 D. The degree of hyperopia will be diminished if the previous refraction has been myopic, and it is possible to produce emmetropia, provided the former near-sightedness has been of such degree that the removal of the lens exactly neutralizes it (see also page 164).

Under ordinary circumstances the correcting lens for distant vision is about + 10 D. For reading and similar occupation a lens having a focal distance of 25-33 cm. is added to the distance glass.

In addition to the hyperopic refraction which follows cataract extraction a certain amount of regular astigmatism is the result of the operation, due probably to failure of the wound to heal properly. This astigmatism is generally "contrary to the rule," and is often higher during the first month or two after the extraction, or until cicatrization is complete. Usually not more than 3 D remain permanently, but even 1 D should be sought out and corrected. The astigmatism may diminish during the first two or three months after operation.

Glasses should not be adjusted until all redness has disappeared from the eye, and they should not be worn constantly at first. It is wise to wait from six weeks to two months before ordering the glasses for constant use.

The amount of vision obtained after a cataract extraction varies considerably. Perfect acuity of sight is frequently

secured—i. e.,  $\frac{6}{6} \left( \frac{20}{xx} \right)$ , but more often patients must be content with lower degrees,  $\frac{1}{8}$  or, according to some operators,  $\frac{1}{10}$  of normal vision being considered sufficient to place the case within the category of successes.

Acuity of vision may usually be considerably raised by dividing the capsule of the lens which remains behind, and some surgeons perform this operation almost as the rule (see Operations).

**Dislocation of the Crystalline Lens.**—This may be congenital (*ectopia lentis*), and is then due to a relaxation or absence of the zonula. The displacement ordinarily is *incomplete*, and really consists in a decentration of the lens; but



FIG. 147.—Spontaneous dislocation of lens into the anterior chamber of highly myopic eye (from a patient in the Philadelphia Hospital. Drawing by Dr. Randall).

*complete* congenital luxation is also described. Congenital cases are usually symmetric. Several members of the same family may be affected. Monolateral cases are also described.

In addition to congenital dislocation there are those due to disease of the eye—e. g., choroiditis, malignant myopia, etc.—and those caused by traumatism. This dislocation may also be *incomplete* or *complete*; if the latter, the lens may be dislodged from its normal position backward into the vitreous, forward into the anterior chamber, or, through a wound, beneath the conjunctiva, and even under Tenon's capsule.

**Symptoms.**—If the dislocation is partial, the margin of the lens may be seen as a dark line with the ophthalmoscope, the refraction of the eye will vary according to the point through which it is observed (*i. e.*, through the lens or beyond it), the iris is tremulous from loosening of the suspensory ligament and lack of the support of the lens, and monocular diplopia and impaired or absent power of accommodation are demon-



FIG. 148.—Subconjunctival dislocation of the lens (from a patient in the Chester County Hospital).

strable. If there is complete posterior luxation, the symptoms are much the same as when the lens has been removed by operation, and if the cause of the dislocation is trauma, the symptoms of the injury—*e. g.*, hemorrhage, etc.—may be present.

A dislocated lens usually becomes cataractous, and often causes intense pain and frequent attacks of iritis, or, by occluding the angle of the anterior chamber, may give rise to glaucoma.

**Treatment.**—In partial dislocation an attempt should be made to secure the best vision with suitable glasses. Sometimes it is possible to remove an incompletely congenitally luxated lens by linear extraction following a discission.

In complete luxation into the anterior chamber the lens may be removed by a simple corneal incision. For removal of a lens dislocated into the vitreous humor, provided it is producing irritation, a scoop introduced through a peripheral corneal incision may be employed, or the operation devised by



the late C. R. Agnew may be attempted. In the latter, a double needle or "bident" is thrust into the vitreous humor far enough back to avoid wounding the iris, the handle of the instrument is depressed, the lens is caught and brought forward through the pupil into the anterior chamber, and removed in the ordinary way. Knapp prefers, under these circumstances, after thorough local anesthesia, to expel the lens by methodical external pressure, through an upper corneal section, after removal of the speculum. He presses the edge of the under lid on the lower part of the sclera, directly toward the center of the eyeball. If this fails, he introduces a wire or metal spoon through the corneal section and the pupil, and extracts the lens in this way. The author has employed this method with satisfaction.

If the lens has been dislocated beneath the conjunctiva, it should be extracted through a small incision made directly over it.

After the successful removal of a dislocated lens the eye should be provided with cataract glasses.

**Foreign Bodies in the Lens.**—Foreign bodies lodged in the lens usually cause general opacity. Occasionally the body is surrounded by a small opacity which remains localized. If a piece of steel or iron is imbedded in the superficial layers, it may be dislodged with the electromagnet, and even from the deeper layers by the powerful magnet of Haab. If the lens is opaque, the whole crystalline lens, with the foreign body in it, should be extracted, lest the foreign body become displaced and disappear within the eye. If any difficulty is experienced in deciding the position of the foreign body, or whether a foreign body is really in an opaque lens, the Röntgen rays should be employed. A properly prepared series of skiagrams will practically always decide the question.

## CHAPTER XIV.

### DISEASES OF THE VITREOUS.

**Hyalitis.**—Under the general term *hyalitis*, provided this is understood to refer to the vitreous humor and not to its sheath (the hyaloid), may be included the two types of inflammation of this body—the one connected with *suppuration*, and the other with the *formation of opacities*. Under almost all circumstances the hyalitis arises in consequence of diseases of the uveal tract, retina, optic nerve, or from injury.

**Purulent Inflammation of the Vitreous** (*Suppurative Hyalitis*).—This condition is caused by a penetrating injury, a foreign body, or a purulent choroiditis, for instance, a metastatic choroiditis after inflammation of the cord in newly born children, or after scarlet fever, erysipelas, relapsing fever, basic meningitis, cerebrospinal meningitis, etc.

There is also a good deal of evidence to show that there may be a *spontaneous inflammation* of the vitreous which may manifest itself simply by opacity, or go on to suppuration. Pus in the vitreous may be due to exhaustion and debility consequent upon low fevers, or, in general, the infectious blood diseases. Suppurative hyalitis may be started by an infection which passes through an operation scar from a few months to seven years after apparent healing. Cystoid cicatrices are particularly dangerous in this respect.

**Symptoms.**—If the cornea is clear, a yellowish reflex is seen shining through the pupillary space, there are retraction of the periphery of the iris and bulging of its pupillary border. Usually, one or two synechiæ are present, and the tension is diminished. In addition to this there may be a pericorneal zone of congestion connected with the inflammation of the iris and ciliary body.

When the exudate in the vitreous is circumscribed, the symptoms at the first glance are not unlike those of glioma

of the retina, and the name *pseudoglioma* has been given to this condition, especially as it is seen in children. It is, however, to be distinguished from a true glioma of the retina by the history of the case, the usual presence of the signs of iritis, the retraction of the periphery and bulging of the pupillary border of the iris, and the diminished tension of the globe.

These cases of *pseudoglioma* or *ophthalmitis* are especially noteworthy as they occur in children and young subjects suffering from meningitis. There is purulent inflammation of the uveal tract, with deposits of exudate in the vitreous which give rise to the yellowish appearance which can be seen through the pupil. The retina is detached, and the optic nerve inflamed. The affection has been attributed to an extension of inflammation from the meninges along the optic nerve, but Percy Flemming suggests that the meningitis and ophthalmitis is each the result of a pyemic process. The source of the pyemia may be middle-ear disease. Stephenson urges examination of the pus in the eye for the meningococcus (*diplococcus intracellularis meningitidis*). This micro-organism is also responsible for some cases of purulent conjunctivitis. Among 43 cases of ophthalmitis there have been 7 deaths, 6 from meningitis (see also page 391).

**Treatment.**—If pus has once formed in the vitreous, in the manner just described, no medicinal treatment is of avail; the ball will shrink, and enucleation is usually necessary. Intra-ocular injections of chlorin water have been recommended.

If, during the earlier stages of this affection—for instance, during the course of a low fever—the discovery is made that fine flakes of opacity are beginning to appear in the vitreous, it is possible that a vigorous supporting treatment may save the eye from destruction (Hansell). The possibility of the occurrence of such a condition during low fevers should lead the physician to frequent investigation of the eyes.

The second type of inflammation of the vitreous is that which is attended with the formation of opacities, and hence may be described under the most prominent symptom of the disorder:

**Opacities in the Vitreous.**—These are either *fixed* or *moving*, and vary considerably in shape, size, and somewhat in color. The opacities may appear in the form of membranes, bands, dots, threads, flakes, and strings; or, finally, the entire vitreous humor may give evidence of uniform loss of translucency, which on careful focusing resolves itself into a diffuse, dust-like opacity.

The fixed membranous opacities are usually adherent by two or more points to the choroid, retina, optic disc, and sometimes to the ciliary processes, and even to the posterior capsule of the lens. They may exist as a membrane which crosses the vitreous and covers the optic disc, or as membranous bands running from before backward, and may be coarse, dense, and organized, or fine and more like a cobweb in texture.

*Method of Detection.*—The examination of the vitreous is made after the manner described on page 112.

The rapidity with which the bodies move depends upon the consistency of the vitreous humor; if this is natural, the movement is slow; if it is fluid or semifluid, the movement is correspondingly rapid.

The different layers of the vitreous may also be examined for fixed opacities by means of the upright image in the ordinary way, by first finding the optic papilla, then gradually placing stronger and stronger convex lenses behind the sight-hole of the mirror until a + 16 D is in place, thus bringing everything into focus from behind forward. The observer's head must be close to the observed eye. In the same way Knapp has proposed to make use of the inverted image, gradually removing the convex lens from the eye and bringing into view the parts from behind forward until those which are anteriorly situated are in focus.

The *subjective* symptoms of vitreous opacities depend entirely upon their amount and density. There may be little or no depreciation of central vision, or this may be cut down and even entirely obliterated. Patients frequently complain of black and gray spots before their eyes; sometimes these assume fantastic shapes, and not infrequently these shapes repeat

themselves so constantly that the patient is able accurately to describe them or even to draw them. The same symptoms may appear where there is no organic disease (page 458). Changes in the field of vision, pain, redness of the eye, or similar conditions will depend largely upon associated changes, and usually are absent if the vitreous alone is affected.

**Cause.**—1. *Refractive error*, almost exclusively high degrees of myopia associated with changes in the choroid and the formation of a posterior staphyloma.

2. *Diseases of the eye*, chiefly cyclitis, iridocyclitis, choroiditis, and retinitis.

The shape and character of the opacities vary with the condition which has caused them. In cyclitis and iridocyclitis inflammatory opacities are seen; in chronic and old-standing choroiditis flake-like or thread-like opacities are very common, especially in elderly people, and are probably due to hemorrhages having their origin in the choroid. In syphilitic choroiditis and retinitis, in addition to large, floating opacities, there may be a diffuse mist which resolves itself into the so-called *dust-like opacities* (*hyalitis punctata*), and is almost characteristic of the disease which has caused the original inflammation of the choroid and retina. The situation of these dust-like opacities is either diffuse through the entire vitreous chamber, or in its posterior layers, or anteriorly, in the neighborhood of the ciliary region.

3. *Injuries of the eye*, which have caused a hemorrhage from the choroid or ciliary region. The origin of the opacity is an extravasation of blood. In the latter case, as has already been mentioned, suppuration of the vitreous is likely to occur.

4. *Diseased Conditions of the System, Local or General.*—Exhaustion of infectious blood diseases or low fevers, widespread endarteritis, gout, syphilis, malaria, portal congestion, constipation, anemia, and irregular or suppressed menstruation cause vitreous opacities; also the prolonged action of arsenic.

5. *Absence of Apparent Cause.*—Opacities of various shapes, often fine and thread-like, and commonly seen in old people, occur without evident disease of the uveal tract, retina, or optic nerve. Their presence in some instances is without

serious import. Sometimes the vitreous is studded with minute light-colored spheres; probably a congenital condition, named *asteroid hyalitis* by Benson. White, glistening spots in the vitreous have also been described as evidences of *fatty degeneration*.

It will be seen, from what has been said, that the origin of vitreous opacities is from various morbid processes, and they may represent the result of an inflammation, a hemorrhage, or a degeneration of the vitreous cells or its constituent parts; that in most instances the opacities are secondary to changes in other portions of the eye; but that, both with and without suppuration, a primary inflammation may start in the vitreous body itself.

**Prognosis.**—This depends entirely upon the cause of the vitreous disease. If this has started in a purulent disease of the choroid or a purulent change in the vitreous has taken place, the prognosis is exceedingly unfavorable and the eye goes on to destruction.

If the cause of the disease is syphilis or other constitutional condition amenable to treatment, satisfactory clearing of the vitreous may be expected; even very dense opacities will disappear under proper treatment. When the opacities are due to hemorrhage, the absorption of the clot is not so likely to take place. Both hemorrhagic opacities and others are subject to relapses.

**Treatment.**—In any case of vitreous opacity, provided the general fundus of the eye-ground justifies this, and there is reason to believe that eye-strain in any sense is connected with its cause, suitable lenses should be ordered, but the use of the eyes at close ranges should be discouraged.

In syphilitic vitreous disease the usual remedies are applicable. When the vitreous change depends upon an exhausted condition of the system, supportive measures are indicated.

If the patient is in condition to receive this, excellent results follow sweats with pilocarpin or jaborandi. The drug may also be used in small doses not sufficient to produce sweating, and seems to have an alterative effect. Iodid of potassium and sodium are useful.

If vitreous disease depends upon constipation and portal congestion, in addition to a regulated diet, cholagogue laxatives should be administered. Anemia and menstrual irregularities are evident indications for treatment; in the former case the combination of bichlorid of mercury with iron is useful. If there is an active inflammatory condition, local blood-letting from the temple should be practised; in fact, the treatment then becomes that of the acute inflammation which has started the disorder. The use of the galvanic current has been warmly recommended by some surgeons in vitreous opacities.

A dense membranous opacity, more or less fixed and general, may be subjected to a needle operation. According to Bull, an ordinary discission needle should be inserted in front of the equator of the eyeball and just below the lower border of the external rectus muscle, and the membrane divided.

**Muscae volitantes** (*myodesopsia*) are the black specks and motes often seen floating in the field of vision, especially if the eye is directed toward a bright surface. They follow the movements of the eye, and are especially annoying during the act of reading, as they float across the page. They do not interfere with vision.

There is no true opacity of the vitreous, and the ophthalmoscope fails to detect in these instances any floating opaque particles. They are probably due to the shadows thrown upon the retina by naturally formed elements in the vitreous bodies, perhaps the remains of embryonic tissue; or, according to Gould, to the débris of vitreous catabolic change. Corpuscles in the retinal vessels may be seen by looking through a dark-blue glass at a white cloud. They appear as small oval bodies.

Although of no serious import so far as sight is concerned, they produce an amazing amount of annoyance in nervous and sensitive persons. Patients frequently complain that they obscure an object, floating directly in front of it, and assume exaggerated and fantastic shapes. They are often ascribed by the laity to disorders of digestion and torpidity of the liver,

## Hemorrhage into the Vitreous—Synchysis 459

and are aggravated by the habit which their possessors form of searching for them.

**Treatment.**—Any cause of eye-strain should be removed, and a course of alterative tonics may be ordered. In short, in troublesome cases the treatment is much the same as would be applied to an ordinary case of asthenopia.

**Hemorrhage into the Vitreous.**—As has already been stated, many vitreous opacities result from hemorrhages from the vessels of the choroid, ciliary body, or retina. Hemorrhage into the vitreous may occur in anemia, nephritis, diabetes, arteriosclerosis, myopia, and glaucoma. According to Ridley, if the hemorrhage arises from the retinal vessels, the hyaloid is usually detached and the blood lies between this membrane and the vitreous. If the ciliary body is the source of the hemorrhage, it usually bursts through the hyaloid into the vitreous. Retinal detachment may occur. Injury is a common cause of hemorrhage in the vitreous, and under such circumstances the entire chamber may be so filled with blood that it is easily detected in its natural color as a dark-red clot, sometimes being so dense that no reflex comes from the fundus.

Finally, in certain cases, generally in young male adults, *spontaneous hemorrhage* into the vitreous occurs, together with hemorrhage in the retina. According to Eales, such patients are liable to constipation, irregularity of the circulation, and epistaxis. Hutchinson thinks that gout may be a cause in some cases. There is marked disturbance of vision depending on the density of the clot, which is likely to be imperfectly absorbed.

**Treatment.**—This consists in local depletion, cardiac sedatives, laxatives, and later the administration of small doses of iodid of potassium or sodium. As in other vitreous changes, if the general condition permits it, a sweat-cure may be tried, either by means of the Turkish bath or with pilocarpin.

**Synchysis** (*Fluidity of the Vitreous*).—This is a softened or fluid condition of the vitreous, which, as has already been implied, can be positively diagnosticated, or, rather, assumed to be present, only by noticing the rapid movement of particles



of opacity contained within it during motions of the eye. Although tremulousness of the iris is sometimes seen when there is decided fluidity of the vitreous humor, this symptom does not prove its condition, but only a lack of support by the crystalline lens owing to relaxation of the zonula. The tension of the eyeball may be diminished.

It occurs in elderly people with disease of the choroidal coat and with staphyloma. A fluid vitreous may be a complicating circumstance in an eye in which an operation is performed; for instance, in a cataract extraction, sometimes causing excessive loss of the vitreous after the corneal incision.

**Synchysis scintillans** is a term applied to a fluid vitreous which holds in suspension numerous scales of cholesterin which move with great rapidity across the ophthalmoscopic field and produce a striking picture, resembling a shower of brilliant crystals. Poncet has reported in this connection tyrosin and crystallized phosphates, but recent investigations seem to show that the appearance is due solely to cholesterin.

The affection probably depends upon a choroiditis, and is said to be more common among alcoholic subjects and those with arthritic tendency or any serious disorder of nutrition. The affection is, however, clinically at least, seen in eyes which apparently are not diseased in other portions, especially in old people, and may be present in advanced degree without depreciation of visual acuity.

**Treatment.**—This does not appear to have any influence. Succinate of iron has been recommended. The condition is a distinct contraindication to operative measures upon the eye.

**Blood-vessel Formation in the Vitreous.**—Occasionally cases are examined which present an entirely new blood-vessel formation in the vitreous in front of the entrance of the optic nerve (Fig. 149).

Only a few vessels may be present, or, in extreme cases, the entire disc is obscured by a congeries of contorted vessels, the whole forming an extensive vascular veil of anastomosing capillaries coming directly from the nerve-head and having no connection with the retinal vessels (Harlan). The vessels may

owe their origin to vitreous hemorrhages; in other cases the origin probably is of a specific nature (Hirschberg).

**Foreign Bodies in the Vitreous.**—These are usually chips of steel, splinters of glass, or small shot. They may reach the vitreous by penetrating the sclera directly or by passing through the cornea and lens. The foreign body, if unremoved, may cause suppurative hyalitis in the injured eye, or sympathetic ophthalmitis in the fellow eye. The symptoms, diagnosis, and treatment of foreign bodies in the vitreous have been included with injuries of the sclera on pages 334, 336.

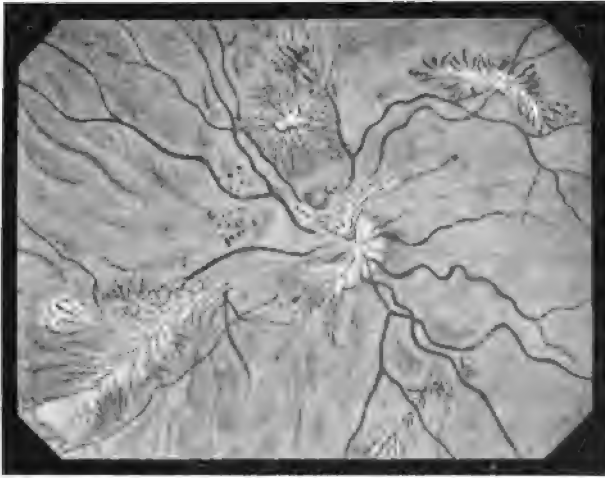


FIG. 149.—New blood-vessel formation in the vitreous.

**Entozoa in the Vitreous.**—*Cysticerci* in the vitreous are exceedingly rare, except in Northern Germany.

Another parasite which has been seen in the vitreous, the removal of at least one specimen being on record, is the *filaria sanguinis hominis*.

**Detachment of the vitreous** is a condition which, of itself, would not create blindness; but because it produces detachment of the retina, it is a change of the gravest import.

Traumatism, choroiditis, hemorrhages, intra-ocular growths, and staphyloma may cause it. The vitreous humor is said to

be occasionally detached without change in its translucency, although opacities are usually present. Shrinking of the vitreous after a blow on the eye causes its hyaloid to be detached from the retina. In eyes removed after injury, stretching across the globe behind the lens, the so-called *cyclitic membrane* may be seen.

**Persistent Hyaloid Artery.**—During fetal life the vitreous humor is traversed by the *hyaloid artery*, which is an extension of the central artery of the retina, and proceeds from the optic nerve to the posterior surface of the lens. The vessel passes through a channel, having a delicate membranous lining, known as the *canal of Cloquet*. Obliteration of this artery begins at the end of the fifth month of gestation.

Sometimes obliteration fails, and the most important congenital anomaly of the vitreous is evident—namely, the persistence of some vestige of the hyaloid artery. It may appear in the following forms:

A rudimentary strand attached to the disc; a strand attached to the disc and a vestige also at the posterior surface of the lens; a strand passing from the disc to the lens; a similar strand containing blood; a strand attached to the lens alone; and a persistent canal (canal of Cloquet) without any remnant of the vessel. These are the most ordinary and well-recognized forms.

In addition to this, shreds of tissue and membranes on the optic disc, masses resembling connective tissue, and small cystic bodies are probably remnants of this artery. Its rôle in producing posterior capsular cataract has already been described. The appearances are readily recognized by the ophthalmoscope, and require no further description than the names already given.

This classification has been condensed from the admirable monograph of Dr. De Beck who has written a most complete account of the anomaly.

## CHAPTER XV.

### DISEASES OF THE RETINA.

**Hyperemia of the Retina.**—This condition, independent of a true inflammation, is not readily demonstrable with the ophthalmoscope.

Although the capillary network of the retina, invisible under ordinary circumstances, may, under other conditions, become evident (*capillary congestion*), the presence of a congestion is inferred, not by any alteration in the appearance of the retina itself, but by changes in the surface of the optic disc, generally known by the terms "*increased redness*" or "*undue capillarity*," and is associated with increase in the amount of the retinal striation which surrounds the papilla, so that its edges are veiled or slightly blurred. Such appearances are common in asthenopic and ametropic eyes, and in persons whose occupations expose them to the glare of artificial heat—*e. g.*, puddlers.

It is possible to speak with more confidence of a change in the caliber, course, color, and general size of the retinal vessels, or, in other words, of a hyperemia of the central system. Under these circumstances more than the normal amount of blood finds its way into these vessels, which consequently are distended, tortuous, or positively lengthened. Gowers divides hyperemia into an *active* type, when the increased amount of blood is sent to the retina because the systemic circulation is unduly filled—*e. g.*, in rapid action of the heart with fever, pneumonia, etc.; and a *passive* type, when there is failure of the blood to be returned from the eye, for example, in compression of the retinal vein. Then the veins are large, filled with dark blood, and often tortuous, while the arteries are unaffected or are smaller than usual.

Among the *general causes* of a stasis hyperemia may be

mentioned mitral disease, emphysema, violent cough, convulsive seizures, or, in short, any cause which is likely to produce engorgement of the veins of the head and neck, and to prevent the emptying of their contents into the great venous channels of the chest. Increase in the diameter of the veins is much more frequent than increase in the diameter of the arteries, while, on the other hand, increase in the diameter of the arteries is uncommon as compared with a diminution of their caliber (Loring). Pathologic significance must not be ascribed to apparent changes in the diameter of the veins, because eye-grounds are often crossed by large dark veins, the arteries being small by contrast, without definite local or general cause for the phenomenon.

Ordinarily patients with hyperemia of the retina do not complain of characteristic symptoms, but when this condition is connected with ametropia there are ocular pain, photophobia, and lack of eye endurance.

**Treatment.**—In hyperemia dependent upon refractive asthenopia the evident treatment is physiologic rest under the influence of atropin, and later a suitable correction with glasses. If severe, blood may be abstracted from the temples or dry cupping may be employed, and internally, bromid of lithium or sodium, with or without ergot, acts well. When the condition depends upon general causes, these furnish the indications for treatment.

**Anemia of the retina** should be looked upon not as a disorder of this structure, but as a symptom of local pressure or of some cause situated within the general economy.

The highest type of anemia of the retinal vessels is seen with stoppage of the circulation by an embolus, and occurs in marked degree as the result of compression, in consecutive atrophy of the optic nerve. Other causes of anemia of the retina are general anemia, cerebral anemia, and syncope.

Extreme narrowing of the retinal arteries is occasionally seen as the result of a vasomotor spasm—for example, in “sick headaches” and in true migraine. In these cases there may be temporary complete or partial (hemianopic) blindness. If the blindness approaches from above downward, the ob-

struction is in the retinal circulation, but if it assumes a lateral form, the cortical visual centers are probably affected (Priestley Smith). Impeded retinal circulation may be attributed to the high arterial tension which is known to be present in some cases of migraine.

Under the name *ischemia of the retina* a condition is described in which, with complete blindness, there are pallor of the optic discs and extreme narrowing of the retinal blood-vessels. This has been seen in the collapse stage of cholera (Graefe), in whooping-cough (Knapp, Noyes), in erysipelas (Ayres), and under the influence of toxic doses of quinin and salicylic acid.

**Treatment.**—The flagging circulation should be stimulated by digitalis and strychnin. Nitrite of amyl has been employed in spasm of the retinal arteries. General anemia calls for its appropriate remedies.

**Hyperesthesia of the Retina.**—This is characterized chiefly by the *symptoms* which indicate a supersensitive state of the retina—dread of light, lacrimation, blepharospasm, neuralgic pain, and imperfect eye endurance.

Ophthalmoscopic changes may be practically absent, but in most instances those lesions will be detected which have been referred to under *congestion*, but which, adopting a name originally employed by Jaeger and used by Loring, may be described as *irritation of the retina*. These are: undue redness of the nerve-head, veiling of its nasal edges, from which, and from those above and below, distinct striation of the retinal fibers are evident, while streaks of light tissue can be followed along the course of the larger vessels. The margins of the disc are veiled by this retinal striation, and although the physiologic cup, if present, or the "light spot," may be unchanged, the general surface of the disc seems to be covered by a delicate layer of edematous tissue. At the same time the choroid reveals changes similar to those described on page 379, or else is distinctly granular and macerated. Often the entire fundus fails to present a distinct ophthalmoscopic picture, and may be described by saying that the details of the eye-ground are not sharply seen by the aid of any correcting glass.

**Causes.**—Hyperesthesia and irritation of the retina are usually caused by errors of refraction and anomalies of muscle balance, especially in neurasthenic and hysteric subjects. They are also seen with chronic headache, neuralgia, sexual abuses, and after prolonged fevers and pulmonary disorders. In a series of cases which the author has reported, oxaluria appeared to be the source of the trouble.

In some instances of retinal irritation the cause seems to be dependent upon changes in the nasopharynx; for example, engorgement of the septum, associated with myxomatous and hypersensitive spots, vasoparetic and infiltrated turbinals, and secondary changes in the pharynx and larynx. Just as areas of hyperesthesia in these regions may be part of a general neurosis, so, also, they may be both directly and indirectly connected with a hyperesthetic condition of the retina, and the eyes will not grow comfortable until the nasal disease is cured. It is probable that retinal irritation may sometimes be the forerunner of organic change in the optic nerve (Loring).

**Treatment.**—Spectacles are not a panacea, and although even slight errors of refraction should be neutralized, the correcting lenses alone do not suffice to relieve the symptoms. General tonics, rest, massage, and all measures calculated to overcome debility or existing neurosis are required. Although strychnin is usually indicated by the general conditions, it may aggravate an irritable retina precisely as it does irritations of nervous tissue elsewhere. The nasopharynx should be explored. The urine should always be examined, especially with reference to uric acid and oxalate of lime; in fact, a thorough examination of all organs should be instituted and treatment directed according to the findings. Retinal irritation is apt to be exceedingly stubborn.

**Anesthesia of the retina** (*neurasthenic asthenopia*), like several other disorders of the retina, just considered, should be regarded not as an affection peculiar to the eye, but as one of the symptoms of a complicated neurosis. Very often the condition described in the preceding paragraph and the present affection are closely allied, and with neurasthenic asthenopia there may be marked hyperesthesia and irritation

of the retina. On the other hand, such appearances may be entirely absent.

The *subjective symptoms* of this condition have been arranged by Wilbrand as follows: Peculiar contraction of the field of vision; rapid disappearance from view of any object which is being fixed; diminution of central vision; sudden attacks of obscuration of vision and processions of scotomas; visual hallucinations; lack of fixation of the optical memory images; inability to read for any length of time; weariness on the part of the muscles both of the eyes and of the eyelids; and positive insufficiency of the internal recti. In addition to this there may be defective accommodation, intolerance of light, and improvement of vision in the dusk or through tinted glasses.

The most characteristic symptom of the affection is a peculiar contraction of the field of vision, which at the beginning of the examination may present normal limits, but as the examiner proceeds, contracts most markedly both above and below the horizontal meridian, because the nervous apparatus becomes fatigued. If the patient is allowed to rest, and the examination is repeated, but the test-object is now moved along the meridians in the opposite direction from that in which it was moved in the first examination, a second field will be obtained, which is called by Wilbrand the *counterfield*. The most contracted part of this counterfield lies on the same side as the most expanded part of the previous visual field. The visual field for colors exhibits about the same conditions as that for white. This is not only characteristic of retinal anesthesia, but of the retinal exhaustion which is found in a variety of conditions.

Patients affected with this condition are for the most part women, often the subjects of ovarian and uterine disease, hysteria, and chlorosis. It is not an uncommon affection about the time of puberty. Although by far the most of its subjects are women, pure types are also seen in men.

In addition to the local symptoms described in connection with the visual organ, these patients have a host of general disturbances indicative of their defective nutrition and nervous



tone. In short, they complain of that series of symptoms which has been classified under the much-abused term *neurasthenia*, or increased excitability of the nervous system, with a tendency to rapid fatigue.

**Treatment.**—This is directed largely toward the general condition, and includes in the most advanced types all that is meant by the term “rest-cure,” namely, rest with seclusion, forced feeding, massage, and electricity. Tonics of various kinds are indicated, and ascending doses of *nux vomica* and strychnin are especially valuable, provided the retinas are not distinctly congested. Under proper circumstances, other cases are suitably treated by graduated exercise.

Although tinted glasses are recommended, they are not always advisable lest the affected eyes becomes too much accustomed to the dull light afforded through such protection. Any error of refraction should be corrected, but spectacles of all types, and all treatment directed toward the ocular muscles, are not alone sufficient to cure these cases—cases, moreover, which are constantly subject to a relapse of their symptoms.

**Retinitis.**—Under the general term *retinitis* are included the various types of inflammation of the retina.

**Varieties.**—Retinitis may be *primary*, owing to constitutional causes and altered states of the blood and blood-vessels; or *secondary*, owing to extension from an inflamed iris, ciliary body, or choroid. It is further divided, according to its character, into *circumscribed* and *diffuse* retinitis; according to its pathologic nature, into *serous* and *parenchymatous* retinitis; and according to its supposed etiology, into the various clinical types presently to be described.

**Pathology.**—In the acute stage of retinitis the retina shows edema and infiltration with leukocytes and red blood-corpuscles. White areas are visible, due to fatty degeneration of both nervous and supporting tissues, varicosity and swelling of the nerve-fiber, and to masses of fibrinous exudate in the granular and nuclear layers. The blood-vessels are thickened, often obliterated, and the supporting tissue hypertrophies. In the later stages of atrophy the retina consists of a connective-

tissue network which contains many pigment-cells; the nervous elements disappear, and the blood-vessels are converted into solid cords.

**Symptoms.**—Certain *objective* and *subjective* symptoms are present in most of the forms of retinitis.

1. *Loss in the Transparency of the Retina.*—This may manifest itself as a faint, diffuse haze, a circumscribed opacity and swelling, or as streaks of white infiltration, especially along the lines of the larger vessels.

2. *Areas of Exudation.*—These are an advanced stage of the condition just described. They appear as white spots, sometimes discrete, sometimes confluent, or as patches of bluish-gray, buff, or yellowish color. They should be differentiated from the shining white plaques due to atrophy of the choroid by their softer tone, their situation, and because there is an absence of accumulation of choroidal pigment. They may be present anywhere in the retina, or localized in the macular region.

3. *Tortuosity of the Vessels and Change in their Caliber.*—The veins are darker than normal, unduly wavy in outline, or positively lengthened in their course. The arteries may not be materially changed, but the finer transverse branches are often very tortuous, and both sets of vessels are liable to displacement from their normal level as they cross areas of thickening, or to partial obscuration by the puffy and infiltrated retina. Many vessels invisible in health become injected in retinitis and form a fine red striation, passing from the nerve-head. Pulsation of the vessels is readily induced by pressure.

4. *Hemorrhages.*—These occur either in the fiber-layer or the deeper portions of the retina. The presence of retinal hemorrhage alone, however, does not indicate the existence of inflammation, as it may occur quite independently of retinitis.

When the hemorrhage is placed in the nerve-fiber layer, it usually assumes a *flame-shape*, with frayed or feathery edges; when its situation is in the deeper layers, it has a cleaner-cut border and more rounded shape.

5. *Changes in the Nerve-head*.—More or less change in the optic papilla is present: undue redness, loss of the distinctness of its margins, obscuration by the swollen and puffy retinal fibers, or finally positive inflammation or neuritis. Atrophy of the disc is commonly present after severe retinitis.

6. *Pigmentation*.—Black spots of pigment mark the situation of former retinal hemorrhages. Pigment in the retina, like hemorrhages, although in many instances a sequence of retinitis, is of itself not necessarily a symptom of inflammation of this membrane.

The difference between pigment in the retina and in the choroid has been described on page 381.

7. *Atrophy of the Retina*.—This, like atrophy of the choroid, may indicate a former hemorrhage or an area of inflammation. All the retinal layers, as well as the choroid, may be involved, exposing a white patch of sclera (*atrophic choroido-retinitis*) or only the superficial layers may be affected, and the spot may be marked by a permanent whitish or yellowish opacity. Contraction of the vessels and white tissue along their coats are often seen after retinitis.

In addition to the ophthalmoscopic signs there are:

1. *Change in Visual Acuity*.—Central vision is *diminished* in direct proportion to the severity of the case and the situation of the inflammatory action. In the early stages of simple retinitis there may be *increased* visual acuity, although this is more common with retinal irritation than with inflammation.

2. *Change in the Field of Vision*.—This may be irregularly or concentrically contracted, or scotomas may appear in its center.

3. *Distortion of Vision*.—This occurs under two forms: (a) Objects appear to be reduced in size (*micropsia*); (b) objects appear to undergo change in their contour or shape (*metamorphopsia*). Vertically placed parallel lines, on the one hand, appear to be bulged outward, and on the other to be bent inward. Fine parallel lines may appear *wavy* to a normal eye.

4. *Pain and Photophobia*.—Acute pain is almost always absent, even in violent forms of retinal inflammation; indeed, it is much more likely to be present in the less pronounced grades.

Usually the sensation is one of discomfort rather than of actual pain. Photophobia may or may not be present. It is never a marked sign, although comfort ensues from the use of tinted glasses.

**Diagnosis.**—The diagnosis of retinitis depends upon the essential symptom of the disease—opacity or loss of transparency in the retina. All the other symptoms which may be present—exudation, hemorrhages, pigmentation, and atrophy—help to make up the clinical characteristics of the various types, but in themselves are not diagnostic of inflammation of this membrane.

Much diagnostic aid is obtained by noting the effect of the disease upon vision, especially under the influence of diminished illumination, and when acuity of sight fails quite out of proportion to the amount of the light reduction, the student should at once be upon his guard. If the coarse changes detailed in the general symptom-grouping are present, the picture is readily interpreted.

**Course, Complications, and Prognosis.**—The course of a retinitis, like any other inflammation, may be *acute* or *chronic*, and its progress of long or short duration. When the retina and choroid are simultaneously inflamed, a common complication is change in the vitreous (*vitreous opacities*), and an almost constant association is inflammation of the optic papilla, leading to atrophy in prolonged cases (*retinitic atrophy*).

The *prognosis* may be favorable, grave, or positively fatal, depending upon the extent of the inflammation, its situation in the inner or outer layers of the retina, and the cause. Before giving a prognosis the surgeon must always attempt to estimate the extent of the permanent disability which is likely to remain in the form of atrophy of the membrane or secondary changes in the papilla. Other things being equal, the prognosis of syphilitic retinitis is the most favorable.

**Treatment.**—This, in general terms, demands perfect rest for the inflamed organ. In sthenic cases, in the early stages, blood-letting from the temple is indicated.

The remedies most likely to afford relief are the various forms of mercury, iodid and bromid of potassium, ergot, and

pilocarpin diaphoresis and Turkish baths. Special methods of treatment are reserved for the sections devoted to the several clinical varieties.

**Serous Retinitis** (*Retinitis Simplex; Diffuse Retinitis; Edema of the Retina*).—This disease is characterized by an infiltration, especially of the nerve-fiber and ganglionic layer of the retina, causing opacity and edema, together with hyperemia, most marked in the veins.

The opacity varies from a delicate veiling to a decided gray-white opacity, most noticeable around the nerve-head, the margins of which are veiled or hidden. From this point the grayish opacity shades out into the surrounding retina. The disc is not swollen: it is simply hidden by the edematous infiltration, or, if the edema is not marked, it is very red and its margins obscured by the radiation of finely injected capillaries from its margins. The veins are dark, fuller than normal, tortuous, and often partly covered by the swollen tissue; the arteries are not much changed in size, unless perchance they may be reduced in caliber by compression. Hemorrhages are rare, and exudations in the macular region are uncommon.

There are no external signs of this form of inflammation. Both direct and indirect vision are affected, the former being "foggy"; the latter concentrically contracted.

**Cause.**—Independently of the fact that it may be the initial change of other forms presently to be described, this type has been ascribed to cold, to exposure, to undue light and heat, and to the influence of refractive error in eyes worked under the disadvantage of imperfect illumination. In other cases it is quite impossible to assign a reason for its development.

**Treatment.**—This is conducted on the general principles already laid down.

**Parenchymatous Retinitis.**—By this term is understood those forms of retinitis in which, in addition to edematous infiltration, opacity of the retina and venous hyperemia, there are pronounced cellular infiltration and structural change leading finally to atrophy of the elements.

Exudations of yellowish or gray color are visible, occurring in patches throughout the eye-ground, and often localized in

a characteristic manner in the macula. Small hemorrhages are commonly present, and the morbid processes may attack the sheaths of the vessels, causing thickening and hypertrophy.

There are no diagnostic external manifestations. Deeply seated pain of a dull, aching character may be present. Vision is often much disturbed, varying from a mere foggy in the outlines of objects to an almost absolute loss of sight. Contraction of the field of vision and positive scotomas are demonstrable, and the phenomena of distortion of objects are apparent. The disease may be circumscribed or diffuse, and localized in the external or internal layers, or affect both of these and also involve the choroid.

**Prognosis.**—This is always grave, and although in certain cases absorption of the products is possible, compression and atrophy of the nervous elements must result in most instances.

**Causes.**—The various constitutional complaints, disturbances of the uterine functions, and intracranial disorders are the most prominent causes.

**Treatment** is governed by the probable exciting cause, together with proper rest for the eyes.

Partaking of the nature of one or the other of these forms there are certain clinical types:

**Syphilitic Retinitis.**—The syphilitic forms of retinal inflammation have been divided by Alexander into: (1) *Choroidoretinitis*; (2) *simple syphilitic retinitis*; (3) *retinitis with exudations*; (4) *retinitis with hemorrhages*; and (5) *central relapsing retinitis*.

The *first form* in the opinion of most authors is really a disease of the choroid, and the pathologic changes of cellular infiltration, exudation, atrophy, and proliferation of the pigment epithelium are found in the choroid, between the choroid and retina, and in the adjacent retinal layers. G. Nagel, however, points out that in specific *retinochoroiditis* there are changes in the retinal vessels—that is, a *syphilitic endarteritis*. The pigment changes are derived from a wandering of retinal pigment. The choroid is markedly altered; sometimes the choriocapillaris completely disappears.

The following signs are visible: Opacity of the vitreous,

especially in the posterior portion, which resolves itself into fine points or dust-like particles, and stretches out to the periphery like a cloud; loss of transparency of the retina surrounding the nerve-head, which may be unduly hyperemic, and on account of the fine opacity in the vitreous, may give the impression that it is swollen; numerous yellowish or white spots of exudation bounded by pigment beneath the vessels of the retina in the periphery of the eye-grounds, and white spots in the macula; and, finally, occasional participation of the iris and posterior layer of the cornea.

The *subjective* symptoms are: Depreciation of central vision, very marked in the later stages; night-blindness and great lessening of visual acuity under weak illumination; irregular and concentric contraction of the visual field and the formation of ring scotomas as well as positive scotomas in the center of the field; and shimmerings, dancing spots and circles (photopsias), and distortion of objects in the form of micropsia and metamorphopsia due to separation of the rods and cones by the effusion.

In the *second form* there appears to be a localization of the disease in the retina, and the ophthalmoscope reveals a gray opacity surrounding the nerve-entrance, this opacity stretching out in lines along the vessels; the papilla is discolored, cloudy, and has been compared to a yellowish-red, oval body seen through a covering of fog. The veins are darker than normal; the arteries usually are not materially changed.

Other objective symptoms are floating vitreous opacities, exudations along the lines of the vessels (*retinitis with exudations, perivasculitis*), and extravasations of blood, usually round in shape, attributed to disease of the vessel-walls (*endarteritis*) or to the formation of thrombi (*retinitis with hemorrhage*). Hemorrhages in syphilitic retinitis, however, are of comparatively rare occurrence.

**Date of Occurrence.**—Diffuse syphilitic retinitis may occur in congenital and acquired syphilis. In the acquired form of the disease it appears from one to two years after infection, sometimes as early as the sixth month, and is found in about 8 per cent. of the cases (Alexander). One eye alone may be

affected, but usually after several months the second eye is also involved.

True retinitis must not be confounded with the so-called "retinal irritation" commonly seen in association with iritis, and the symptoms of which have been described under hyperemia. Retinitis, however, may accompany or follow iritis.

**Course and Prognosis.**—Although the onset of syphilitic retinitis may be sudden, the course is essentially chronic.

The *prognosis* largely depends upon the stage at which treatment is begun and the vigor of the measures employed. Delayed or neglected treatment may lead to the grave consequences of extensive choroiditis, pigmentary degeneration in the retina, and atrophy of the optic disc. Even under favorable circumstances improvement may be temporary and many stubborn relapses occur.

**Treatment.**—The same constitutional measures recommended in the treatment of syphilitic iritis are applicable. Bleeding from the temple has been recommended, but it is difficult to understand upon what grounds.

*Central relapsing retinitis (retinitis macularis)* belongs to the late manifestations of syphilis, and appears in the form of a gray or yellow area in the macula, or as numerous small, yellow or yellowish-white spots and pigment dots, or as a diffuse opacity of this region. The papilla and its surroundings are unaffected. It is a rare form of syphilitic retinitis, stubborn in its character, and prone to relapse.

**Purulent Retinitis (Septic Retinitis).**—This term has been applied to an affection seen in pyemia, puerperal septicemia, putrid bronchitis, and other pyogenic conditions, and is characterized by small, circumscribed white spots near the papilla and in the macular region. Usually both eyes are involved, and numerous small hemorrhages may be seen. These spots are due to fatty degeneration of the capillaries and infiltration of the retinal fibers, and have been attributed to a change in the composition of the blood and to emboli of bacteria.

*Suppurative choroiditis*, described on page 391, may begin in the retina with plugging of the vessels, opacity of the layers and hemorrhages, and under such circumstances may be



looked upon as the violent form of purulent retinitis, or, as it is sometimes called, *embolic panophthalmitis*. Unlike the first variety described, a single eye is commonly affected, although both may suffer. As Loring suggests, the more frequent use of the ophthalmoscope during septicemic conditions would probably disclose the earlier symptoms of this affection, before the vitreous becomes filled with pus, rendering a view of the fundus impossible.

Anatomic investigations have shown that an independent or *primary purulent retinitis* may occur in an *acute* form from a penetrating foreign body, and in a *chronic* form, presenting the clinical picture of suppurative choroiditis.

**Treatment.**—In the severe varieties of this affection which pass into a general ophthalmitis, treatment is practically of no avail; indeed, in pyemic conditions, these are a precursor of death. In the milder forms, the prognosis is not so unfavorable, and recovery from the disease which has caused the retinitis may take place.

**Hemorrhagic Retinitis.**—Although the mere presence of hemorrhages in the retina does not necessarily mean the coexistence of retinitis, if signs of inflammation are added, the term hemorrhagic retinitis is suitable.

In a typical case the appearances are as follows: Swelling of the papilla, its edges being clouded or hidden by an opaque infiltration of the surrounding retina; darkly tortuous and distended veins, but small arteries; and numerous hemorrhages, linear, flame-shaped, irregular, or round in shape.

The size, number, diffusion, and localization of the hemorrhages vary. Thus, they may be everywhere throughout the eye-ground, or grouped especially in the macular region or around the papilla. If white spots are present as the result of degeneration after absorption of the blood, the appearances may closely resemble those seen in so-called renal retinitis, which, indeed, may be one of the types of hemorrhagic retinitis.

**Causes.**—Hemorrhagic retinitis occurs with diseases of the heart and of the blood-vessels—*e. g.*, hypertrophy, aneurysm, and endarteritis; in suppressed menstruation; at the climac-

teric; and in a variety of general and local diseases, sometimes presenting types presently to be described under special clinical designations. More rarely, retinitis with hemorrhages is caused by secondary syphilis.

The hemorrhages in most instances are due to rupture of retinal vessels, whose coats have become degenerated—in other words, they depend upon endarteritis; in other cases they have been ascribed to diapedesis of the blood-corpuscles. The disease is often monocular. No doubt in many cases the presence of the hemorrhages determines the retinitis by causing irritation of the retinal fibers, and in this sense both the extravasation and the inflammation are symptoms of the vascular disease, which is the primary affection.

**Prognosis.**—This is unfavorable because the ocular condition may indicate a grave vascular or cardiac malady, and may be the forerunner of extravasations in vital centers. Sight may be seriously impaired. Secondary changes in the retina and optic nerve are likely to follow; sometimes glaucoma results.

**Treatment.**—In addition to local depletion from the temple and protecting the eye with dark glasses, the therapeutic measures must be governed by the general condition. F. R. Cross recommends subconjunctival blood-letting. Often iodid of potassium is indicated, with or without cardiac sedatives. Ergot has been recommended, and also small, not diaphoretic, doses of pilocarpin. Any congestion of the portal circulation, which in itself may originate the disorder, should be regulated by suitable laxatives.

**Albuminuric Retinitis** (*Renal Retinitis*; *Papilloretinitis*; *Retinitis of Bright's Disease*).—**Symptoms.**—In a typical case, beginning in the macula or its immediate neighborhood, and continuing to be most numerous in this region, variously shaped and placed white spots appear. These at first may be small, discrete, and sharply separated, but later, or under other conditions, they form a somewhat star-shaped figure, the rays of which surround the fovea, but for the most part do not involve it. Occasionally, instead of a stellate arrangement, the white spots and lines, somewhat radially placed like spokes

in a wheel, affect this neighborhood in part, but do not completely encircle it.

At some distance from the papilla, and often surrounding it, larger yellowish-white or white spots are seen, which may coalesce and form a ring-shaped zone around the nerve-head, broader than its own diameter. This striking, wide, white area has been compared to snow, and designated "the snow-bank appearance of the retina."

Another feature, but unlike the white spots having no pathognomonic appearances, are the *hemorrhages*. They may be linear, flame-shaped, or round, or mere flecks scattered here and there, and found with difficulty, or they constitute large, dark-red extravasations. Moreover, they are not constant, like the white spots, but at times disappear, leaving white marks which denote their former situation. Sometimes they occur in great numbers, like fresh explosions. To a certain extent they are indications of the violence of the disease.

The blood-vessels may run over the white plaques, or may be buried in the swollen retina. Sometimes a vessel disappears beneath the infiltration, to reappear at some distance beyond. The veins are dark and often tortuous; the arteries, as in other forms of retinitis, are not materially altered in size. In the later stages the vessels exhibit lack of transparency of their walls, in the form of white tissue along the sheaths, or they are actually converted into white strings.

Finally, the optic papilla and its immediate surroundings may be intensely hyperemic, or a swelling of the nerve-head occurs, quite indistinguishable from that of *optic neuritis*, as it is seen in tumor of the brain. Under any circumstances the edge of the papilla is clouded, but not necessarily swollen, the surrounding retina finely clouded, and traversed with numerous radiating injected lines, like those described in other types of retinitis. Quite commonly the changes in the papilla directly join the band of fatty infiltration already described, surrounding the end of the optic nerve.

The chief, in fact the only, *subjective* symptom is depreciation of vision, which may vary from a slight and gradual impairment to complete blindness. It is a well-known fact that

PLATE III.



Albuminuric retinitis; star-shaped figure in the macula; the circulation in the distended veins impeded where the latter are crossed by the arteries which are undergoing sclerotic changes.



Bright's disease is often discovered by an ophthalmoscopic examination, the patient being ignorant of the fact that he is the subject of serious organic malady. The visual field may be altered according to the situation of the retinal lesions, and may contain blue-blind areas. According to Gerhardt, blue blindness may be a sign of contracted kidney.

**Forms of the Disease.**—Two varieties have been recognized—an *inflammatory* and a *degenerative* type. Often the two are combined.

The former may be present as violent *neurorretinitis* from the beginning, or it may start as a degenerative type and assume inflammatory action. The latter begins without inflammatory changes, the white spots are small, often quite minute, and separated by comparatively normal areas, and the hemorrhages, if present, are inconspicuous, being confined largely to the nerve-fiber layer. If hemorrhages are the most conspicuous feature of the disease, the term *hemorrhagic* is applied; if the changes are almost wholly confined to the optic papilla, the *neuritic* type is developed. Samuel West draws a sharp distinction between two forms of albuminuric retinitis—the *degenerative* and the *exudative*—and brings the former in association with granular kidney and the latter with parenchymatous nephritis. The exudative variety is inflammatory and probably toxic in origin; the degenerative depends on vascular changes.

It is probable that in some instances single small hemorrhages and comparatively insignificant dots in the macula may be the signs of renal retinitis, and consequently of renal disease. In every case of retinal disease the urine should be frequently and thoroughly examined.

**Causes.**—While in general terms Bright's disease is the cause of the retinitis which bears its name, it most frequently occurs with chronic interstitial nephritis. It may also be caused by chronic parenchymatous nephritis. The retinitis seen with pregnancy is most commonly due to albuminuria, and the disorder is also found with scarlatinal nephritis. Usually both eyes are involved, but unilateral albuminuric retinitis is not a rarity (Knies), a certain percentage of cases

maintaining monocular retinal lesions until death. In another large percentage of cases the unilateral character of the affection is temporary, both eyes ultimately becoming affected. The author has observed two unilateral cases.

**Course, Pathology, and Prognosis.**—The course of typical renal retinitis has been divided into the stage of hyperemia of the papilla, opacity of the retina, and hemorrhages; the stage of fatty degeneration; and the stage of retrograde metamorphosis and atrophy.

The white spots may subside, but rarely disappear entirely, the macular changes being most permanent. Discoloration and atrophy of the papilla, contraction of the vessels, and the formation of white tissue along their walls, and pigment changes in the retina finally result.

The *pathologic changes* are found chiefly in the macular region and in a zone surrounding the nerve. The retina is thickened by the presence of an inflammatory edema and by hypertrophy of its nervous and supporting tissue. The glistening spots in the macular region are due to a fatty degeneration of the exudate and of the retinal elements. Their star-shaped arrangement is due to the oblique direction of the fibers of Müller in this position. Many fatty granular cells are seen, and deposits of coagulated fibrin, particularly in the nuclear layers. Hemorrhages are present, but not necessarily a pronounced feature. In the early stages the vessels show thickening of the adventitia, and later pronounced hyaline change and proliferation of the lining endothelium. The nerve in many cases is swollen by the inflammatory edema.

Detachment of the retina, hemorrhage into the vitreous, embolism and thrombosis of the vessels, extravasations into the choroid, and more rarely glaucoma, have been described as *complications* of this affection.

The *prognosis*, so far as vision is concerned, is most unfavorable, except in the mildest forms, and especially, according to West, in the exudative varieties, not only on account of the sequential changes, but also because of the direct involvement of the macula. In so far as the life of the patient is concerned, albuminuric retinitis is a most unfavorable symptom, and the

large majority of the patients die within two years after its appearance, prolongation of life to the end of five to seven years being uncommon.

In the albuminuric retinitis of pregnancy the prognosis in regard to vision and the life of the patient depends upon the duration of gestation. With the termination of pregnancy the inflammatory deposits (the type most often is inflammatory) may subside, and good vision may be restored, provided the process has not continued so long that the secondary changes already described have taken place. For this reason the induction of premature labor has been recommended as a therapeutic measure.

**Diagnosis.**—In wide-spread albuminuric retinitis the changes detailed in the symptom-grouping are quite characteristic, and may be said to be pathognomonic of kidney disease.

Neuroretinitis from intracranial disease may simulate this affection, and often only a careful study of the urine and the general symptoms will establish the diagnosis (see also page 521). The question becomes still more complicated if albuminuria is associated with brain-tumor.

In glycosuria and leukocythemia somewhat analogous appearances are found, and again an examination of the urine, as well as that of the blood, may be necessary before reaching a diagnosis.

The white spots are distinguished from plaques of choroidal atrophy by the absence of pigment-heaping. The snow-bank appearances differ from retained marrow sheath (page 510) by the fact that the latter stretches away from the margin of the disc, usually ending in a fan-shaped border, and is unaccompanied by the changes in the macula or by retinal edema. Fine lesions of the choroid in the macular region may be mistaken for somewhat similar retinal changes; but they are more scattered, more yellow in color, usually unassociated with distinct loss of vision, and less liable to assume a stellate or radial appearance.

**Treatment.**—Local measures are practically of no avail. The case must be managed on the general principles suited to



the form of kidney disease which is present. A proper remedy in most cases is iron, usually in the form of the tincture, and often advantageously combined with bichlorid of mercury.

**Diabetic Retinitis.**—This occurs in several forms. It is always bilateral, but both eyes may not be affected at the same time.

Hirschberg describes two varieties of diabetic retinitis—an *exudative* and a *hemorrhagic* form. They usually are late manifestations of diabetes, and are seen at a time when gangrene, carbuncle, hemiplegia, and other serious complications of this disorder arise. In any case of diabetes of long duration retinitis is seldom absent, although it may sometimes be difficult to find the lesions, because they may exist in the periphery of the eye-ground. This is especially true if the complication of high myopia, or cataractous lens, is present.

More commonly than in the retinitis of albuminuria, opacities and hemorrhages occur in the vitreous humor. The student should never neglect to make an examination for sugar in the urine in any case in which he finds hemorrhagic retinitis or small hemorrhages associated with white spots of exudation, especially around the macula. To a collection of small white spots irregularly arranged in the macular region and between it and the disc, between which are numerous small hemorrhages, the name *central punctate diabetic retinitis* has been applied. By some authors this appearance is considered typical of diabetes.

**Treatment.**—There is no local treatment. The discovery of such a condition may lead to the finding of sugar in the urine, but more commonly the patient is already conscious of his disease and is under medicinal and dietetic treatment.

**Leukocythemic Retinitis.**—The retinal changes seen in splenic leukocythemia, to which variety of the disease they are almost exclusively confined, affect both eyes, usually one more than its fellow.

The most important ophthalmoscopic appearances are slight swelling of the papilla, pallor of its surface, veiling of its edges, and some opacity of the retina, especially along the lines of the vessels. The latter present a striking appearance. The

veins are broad, distended, and of a somewhat rose-red color ; the arteries, in contrast, narrow and orange-yellow, which color substitutes the ordinary fiery red of the choroid, the vessels of which, if they are visible, present a yellowish-red tint.

Very prominent lesions are white spots with red borders, especially near the equator and in the region of the macula lutea. The spots vary in size and are often somewhat elevated in appearance. They are due to a collection of lymph-corpuscles, and the red border to an extravasation of blood-corpuscles.

On the other hand, retinitis associated with leukocythemia may not present characteristic appearances, but may consist simply of a diffuse opacity of the retina, or appear in the form of hemorrhagic retinitis. When the yellow spots which have been described develop in the macula, it is sometimes difficult to distinguish the case from one produced by albuminuria. Indeed, albumin in the urine may be present with leukocythemia. In any doubtful case a careful blood examination will reveal the true nature of the disease.

In addition to the types of retinitis thus far described there are certain rare forms.

**Proliferating Retinitis.**—This affection is characterized by dense masses of bluish-white or white color, which are developed from the retina and stretch out into the vitreous humor. They often cover a considerable portion of the fundus and hide the papilla, which may with difficulty be seen through the intervening spaces. Sometimes the masses follow the course of the blood-vessels, which in part may lie beneath them, and in part pass over them ; those which lie above the masses are occasionally newly formed blood-vessels. As complicating circumstances, there may be detachment of the retina, opacity of, and hemorrhage into, the vitreous.

According to Weeks, the essential of this disease is the production of membranes which extend from the retina into the vitreous humor, and a fibrinous exudation or hemorrhage must first occur before these membranes can be formed. This process and that of vascular growths in the vitreous (page

460), as Marple has well shown, are identical. Three varieties of the affection have been described—idiopathic, syphilitic, and traumatic. The disease is more common in young than in elderly subjects. Vision is greatly impaired, sometimes totally lost.

**Retinitis Circinata.**—This name was applied by Fuchs to an affection characterized by a concentric aggregation of slightly raised white spots and lines around the macula. Sometimes the white spots surround the macula after the

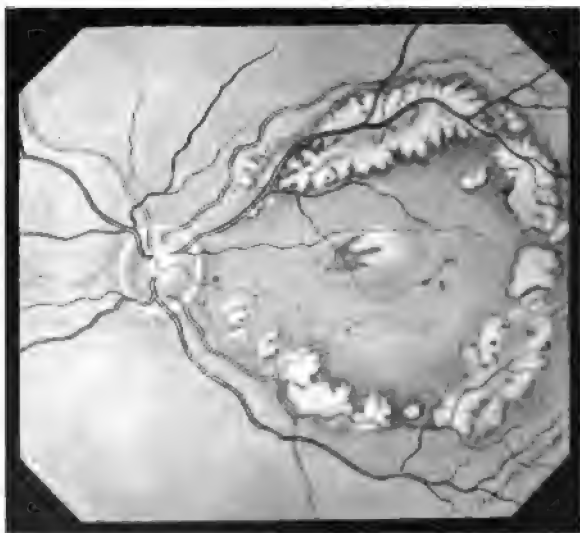


FIG. 150.—Circinate retinitis (from a patient in the Jefferson Hospital).

manner of a wreath ; sometimes the arrangement is more like that of an ellipse, one end of which may touch the edge of the optic disc, while the other extends beyond the macular region (Lawford). Fuchs regarded the white patches as fibrinous exudates which had taken place into the deeper layers of the retina, while de Wecker denies the special character of the disease, which he attributes to fatty degeneration, the result of hemorrhages. Indeed, Amman has shown that the white spots are due to fatty cells clustered where hemorrhages have been. Hemorrhages may accompany the affection, and in

one case (Fridenberg) there was a development of new-formed blood-vessel in the retina.

**Central Punctate Retinitis** (*Retinitis Punctata Albescens*).

—This type of retinal affection was originally described by Mooren, and, according to him, is characterized by a great number of striæ or spots scattered over the fundus, resembling in color the reflex of the sclera. The retinal vessels are not covered by the spots. The papilla is decidedly gray. While the peripheral field of vision is unaffected, in its center there may be either a relative or a positive scotoma. Vitreous hemorrhages have also been described, and in Hirschberg's cases, who calls the disease *central punctate and striated retinitis*, atheromatous changes in the vessels elsewhere in the body were found. Recently Fuchs has called attention to the similarity of this disease to retinitis pigmentosa, inasmuch as it is either congenital or starts in infancy, affects several members of the same family, and may occur in the children of blood relations. Also, there may be night-blindness and contraction of the visual field. As John Griffith has pointed out, it should be regarded as a primary degeneration of the retina and choroid allied to pigmentary degeneration of the retina, and should not be classified as an inflammatory disease. Another type of chronic retinal degeneration is that to which Fuchs gives the name *atrophia gyrata choroideæ et retinæ*, also seen in the children of consanguineous marriages and associated with night-blindness.

**Treatment.**—This consists in depletion from the temple, and iodid of potassium or other alterative of similar physiologic action.

**Retinitis Striata.**—Occasionally light or yellowish-white stripes extending from the periphery toward the disc, and sometimes bordered by lines of pigment, lying beneath the retinal vessels, are apparent to the ophthalmoscope. To this appearance the name retinitis striata has been given, and while the origin of the affection is not positively known, it is probable, as Holden contends, that the stripes are the result of the metamorphosis of retinal hemorrhages, and in this respect are analogous to angioid streaks. On the other hand, it has been

contended by L. Caspar that these retinal striations represent the final stages of spontaneously cured detachments of the retina.

**Pigmentary Degeneration of the Retina** (*Retinitis Pigmentosa*).—Although this affection is usually entitled *retinitis pigmentosa*, the phenomena of inflammation are absent, and it consists of a degeneration of the nerve tissue, associated with great contraction of the blood-vessels and the accumulation and deposition of pigment of well-nigh characteristic form in the substance of the retina.

**Symptoms.**—The ophthalmoscopic appearances of a typical case are as follows:

(a) *Pigmentation.*—The pigment-masses assume an appearance resembling bone-corpuscles, and by the frequent union of their processes simulate the Haversian canals. By preference, the pigmentary depositions are more marked on the temporal side. They begin far out in the periphery of the eye-ground, often lying along the course of the main vessels, and gradually approach the papilla, the macular region remaining for a long time unaffected. A zone midway between the center and far periphery is the favorite seat of pigmentation.

(b) "*Wainscotted Fundus.*"—A perfect picture of the appearance already described in connection with superficial choroiditis is visible on account of the absorption of the retinal pigment epithelium and the exposure of the larger vessels of the choroid. The overlying retina is distinctly gray.

(c) *Contraction of the Vessels.*—This is present in both systems. The vessels may be as thin as threads. Often their walls exhibit patches of opacity, and they are accompanied by fine white lines. Not only are they greatly contracted, but they are apparently diminished in number.

(d) *The Changed Nerve-head.*—The color of the papilla, according to the stage of the disease, is of a yellowish-gray, yellowish-red, or waxy tint. It finally becomes dull white and atrophic. Except a slight veiling, its edges are plainly marked.

(e) *Opacities of the Media.*—Posterior polar cataract may be a complication. Opacities in the vitreous are uncommon.

(f) *Nystagmus*.—Quite frequently a quick lateral oscillation of the eyeballs, or nystagmus, is present, especially in congenital cases.

The subjective symptoms are :

(a) *Depreciation of Central Vision*.—Visual acuity may be but slightly affected in the earlier stages, although usually the perception of green and red is below the normal (Oliver). Indeed, reasonably good central vision may remain, even when the disease is very wide-spread, but it finally sinks with the progress of the affection.

(b) *Contraction of the Field of Vision*.—This is concentrically

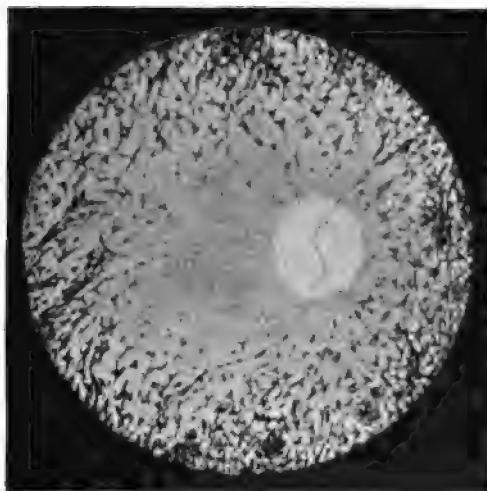


FIG. 151.—Pigmentary degeneration of the retina (Jaeger).

contracted according to the amount of degeneration, and the contraction may be so excessive that only a very small area of the field remains. In rare instances, even with extreme narrowing of the visual field, there is still moderately good central vision, and the patient may read by fixing a single word at a time. Finally, the contraction goes on to complete blindness. The defect in the field may also be irregular, according to the position of the areas of degeneration, and it sometimes assumes the form of a broad, ring scotoma.

(c) *Night-blindness*.—Often this is the first symptom which

calls attention to the case. The patient is uncertain in his movements and stumbles as soon as twilight begins, becoming quite helpless in the dark. Night-blindness is not always present, and in rare instances diminished light is a relief to the patient. Such a condition is due to retinal hyperesthesia.

**Atypical Varieties.**—The pigment may be massed in the macular region. Then the central vision is much affected, and a scotoma appears around the point of fixation. In other instances the pigment-masses are scattered all over the fundus in irregular masses, and are associated with clear, shining spots lying beneath the retinal vessels. Cases occur presenting the usual subjective symptoms, but without the accumulation of pigment—really forms of *sclerosis of the retina without the formation of pigment*—and a few instances, associated with a broad peripheral zone of choroidal atrophy, have been described. Finally, in rare instances, retinitis pigmentosa may be complicated with chronic glaucoma, the retinal affection probably antedating the glaucoma (Bellarmino, Mandelstamm).

**Causes.**—The disease is markedly hereditary. In numbers of instances consanguinity of the parents of the patient has been found; indeed, the disease has been attributed to this alone. Hereditary syphilis has been given as a possible cause of retinitis pigmentosa, but this has not been proved. The affection is found among deaf-mutes, idiots, and epileptics, and in this sense is connected with morbid states of the nervous system. Very often no cause can be assigned. The disease is either congenital or begins in childhood.

**Pathology.**—The degenerative process begins in the outer layers of the retina, which becomes adherent to the choroid. The rods and cones disappear, the blood-vessels are sclerosed, and their lumens contracted. Later the sclerotic process reaches the layer of ganglion-cells and the nerve-fibers. There is a marked infiltration of pigment-cells along the thickened vessels. The optic nerve atrophies and may show hyaline masses similar to those in the lamina vitrea of the choroid. Wagenmann believes that the primary lesion is a sclerosis of the vessels of the choroid. The beginning of the disease has

## Pigmentary Degeneration of the Retina 489

also been placed in the pigment epithelium. The affection is always bilateral.

**Diagnosis.**—A fully formed and typical case of retinitis pigmentosa presents no difficulties in diagnosis. It may be distinguished from disseminated choroiditis by the difference in the pigmentation of the two diseases.

Its differential diagnosis from certain types of retinochoroiditis seen in acquired syphilis is difficult, especially when the latter manifest themselves in the form of atrophy of the retina and a gathering of pigment spots, beneath which the exposed choroidal vessels are visible. In retinochoroiditis, however, the pigment spots do not have the characteristic form; they are much scattered, and do not follow the blood-vessels; besides, vitreous opacities, which are very rare in pigmentary degeneration of the retina, are usually present.

A patient complaining of night-blindness, or seen stumbling about during the twilight, should be subjected to a careful examination of the far periphery of the eye-ground, if necessary after dilatation of the pupil, because occasionally the pigment is confined to this region and might be overlooked by a careless observer.

**Course and Prognosis.**—Pigmentary degeneration of the retina having begun in childhood, progresses steadily onward with ever-increasing contraction of the field of vision, until finally, usually by middle life, sight has been obliterated, with, perhaps, the exception of a slight eccentric preservation of the field. The prognosis is hence unfavorable under all circumstances and in spite of all known endeavors to modify the course of the disease. Occasionally, when the pigment accumulation has advanced far over the retina, but the macula still is free, the disease remains stationary for long periods of time.

**Treatment.**—This is of little avail. Strychnin in full doses, especially by the hypodermic method, has been recommended. If there is any suspicion of syphilitic taint, the usual remedies are applicable. Galvanism has been tried, and under its influence it is stated that the progressive contraction of the field of vision has been stayed, although no improvement in the



acuity of central sight was obtained. It certainly should be given a trial in every case.

**Detachment of the Retina** (*Ablatio Retinæ*; *Amotio Retinæ*).—Idiopathic separation of the retina from the underlying choroid is due to an accumulation of a serous fluid between these membranes.

**Symptoms.**—The student will observe, as he examines the various portions of the fundus with the ophthalmoscope (direct method), an alteration of refraction at the area of sepa-



FIG. 152.—Detachment of lower half of retina, which has floated forward. Disc and upper half of fundus dimly seen.

ration, the surface of the elevation thus produced being out of focus as compared with the rest of the eye-ground. Thus, if the general fundus is hyperopic, the detached portion will be more hyperopic, and require a stronger convex glass for the study of its surface; if it is highly myopic, a weaker concave glass, or, it may be, a low convex lens.

The normal color of the fundus is lost as the detached retina is approached, which appears as a gray or bluish-gray membrane stretching forward into the vitreous, containing folds which give rise to a sheen. The intervening furrows present a greenish-gray reflex, and the whole oscillates with the

movements of the eye when the underlying substance is fluid; if it is a solid, neither folds nor tremulousness are present. Rents in the detached retina, through which the choroid is visible, are often demonstrable.

The retinal vessels rise over the separated portion, first lose the light-streak, and finally appear as dark, tortuous cords. They apparently are of smaller size than normal, and when followed backward they pass out of focus at the edge of the detachment, which is usually sharply marked from the normal fundus; indeed, there may be a yellowish border and occasionally accumulated pigment. The amount of discoloration of the detached area depends upon whether the case is recent or not, and upon the character of the underlying substance. In the earlier stages transparency is not lost, and the gray color, previously described, may not be present.

The detachment, either *partial* or *complete*, may occupy any portion of the fundus, but most commonly is found below, even when it has begun in the upper part. Sometimes the detachments are quite small, like a series of furrows, and at other times an almost circular circumscribed separation occurs. Finally, the subjective signs of detachment may be present without discoverable elevation of the retina, but over the area (which subsequently separates) there is complete loss of the light reflex from the retinal vessels (Loring).

Unless the macular region is directly involved, vision is not obliterated, but there is always interference with sight. This may develop suddenly. The field of vision is lost in an area corresponding to the detached retina, and the completely darkened portion is usually bordered by a zone of imperfect vision corresponding to an area of retina not yet separated, but elevated above its normal plane. If the retina is detached below, the upper portion of the visual field is obliterated; if above, the lower portion, and so on (Fig. 153).

The patients complain of distortion of objects (metamorphopsia); of floating spots before the eyes, due to the frequent presence of vitreous opacities; of an appearance like a cloud, due to the scotoma produced by the separated area; and of

phosphenes, although the last cannot be elicited by pressure on the eyeball over the separated area.

**Causes.**—The causes of retinal separation are : High (malignant) myopia ; traumatisms ; effusion of blood, preceded usually by hemorrhages into the vitreous or retina ; intra-ocular tumors (sarcoma of the choroid) or subretinal parasites (cysticercus) ; tumors and abscesses in the orbit, and diseased conditions of the eye, as retinitis, cyclitis, iridocyclitis, etc. In the last in-

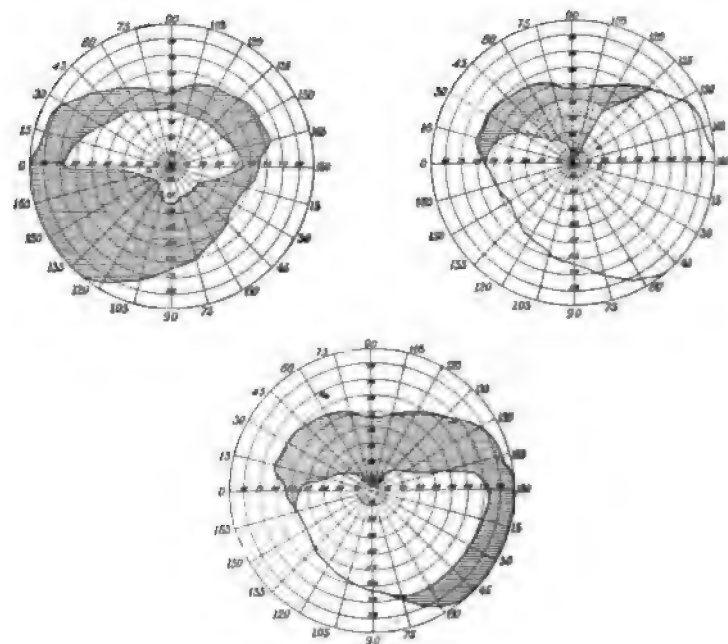


FIG. 153.—Various types of fields of vision in detachment of the retina.

stances the detachment is found after removal of the shrunken globe. More men than women are affected, myopic refraction most frequently is present, and the separation is more apt to occur in an eye in which the visual disturbance has rapidly developed. The condition may become apparent suddenly, especially after sudden effort, or arise slowly.

**Mechanism.**—Leber and Nordenson hold that the first process is a fibrillar change in the vitreous, which shrinks and

occasions traction. This ruptures the retina, and the fluid from the vitreous cavity passes beneath it through the opening. The primary cause of the pathologic alteration in the vitreous is believed to be disease of the choroid and ciliary body. Raehlmann explains the detachment by a diffusion theory, the conditions being analogous to transudations in other parts of the body. In some instances retinal detachment must be explained by the presence of exudation or hemorrhagic extravasation.

**Diagnosis.**—No difficulty arises in detecting a large detachment of the retina by attending to the symptoms already detailed. An extensive or complete detachment which floats far forward may be examined by oblique illumination. When the vitreous is full of opacities, a study of the field of vision is useful. When the substance underlying the detached portion is *fluid*, there are usually diminished tension of the eyeball and the appearance of furrows in the separated tissue, which trembles with the movements of the eye, symptoms which are absent when a *solid growth* has caused the separation. Important diagnostic signs are the loss of the light-reflex of the vessels, and their dark color over the area of separation. They can be seen to regain the light-reflex in passing over the normal retina.

**Prognosis.**—This is very unfavorable, and many of the suggested means of treatment have proved unsatisfactory. In rare instances there is spontaneous reattachment of the retina.

**Treatment.**—This should include rest in the prone position, a light pressure bandage, and pilocarpin sweats, the pupil of the affected eye being dilated with atropin. The iodids and mercuric bichlorid may be tried, and improvement after instillations of eserine has been reported. Repeated small doses of salicylic acid appear to act favorably in some cases.

Various forms of operative procedure have been attempted: sclerotomy and iridectomy—the latter should not be practised; evacuation of the subretinal fluid by puncture and aspiration, and drainage by means of a gold wire. Schoeler has reported successes after the intra-ocular injection of iodine and the production of sufficient inflammation to reunite the

choroid with the separated retina. This method, according to Bull, should be condemned. Evacuation of the subretinal fluid by means of scleral puncture is occasionally efficacious. Subconjunctival injections are also valuable. For this purpose de Wecker employs a solution composed of  $3\frac{1}{2}$  parts of gelatin with 100 parts of physiologic salt solution. Jocqs advocates injections of a saturated solution of salt in conjunction with scleral puncture, while Bourgeois recommends a 30 per cent. salt solution to which a few drops of a 5 per cent. solution of cocain are added, 1 c.c. of the fluid being injected. The author has had good results with scleral puncture, followed by large (30-minim) injections of physiologic salt solution. During the treatment the patient should remain in bed. Scleral cauterization, followed by subconjunctival saline injections, has been employed by Dor. If the detachment is due to a tumor, the eye should be enucleated.

The following phenomena are especially concerned with pathologic changes in the blood itself, the perivascular tissues and the vessel-walls, and are indicative both of local disease or, as in many of the inflammatory stages, of disease in distant organs:

**Hemorrhages in the Retina** (*Apoplexy of the Retina*).—

The appearances of retinal hemorrhage have been described in the general symptom-grouping, and as they occur with so-called hemorrhagic retinitis.

Hemorrhages (unassociated with inflammation) may be in any of the layers of the retina, or, bursting through the limiting membrane, they may occupy the vitreous humor. By preference they are found along the course of the larger vessels; a favorite site is the macula. Hemorrhages originating in the outer sheath of the optic nerve may appear at its margin and spread into the surrounding retina.

Hemorrhages of large dimensions and drop-like form usually mean an extravasation between the internal limiting membrane of the retina and the hyaloid membrane of the vitreous, and they come from a retinal vessel. These *subhyaloid hemorrhages* tend to occur at the yellow spot more than at other parts of the fundus. According to J. Herbert Fisher, the

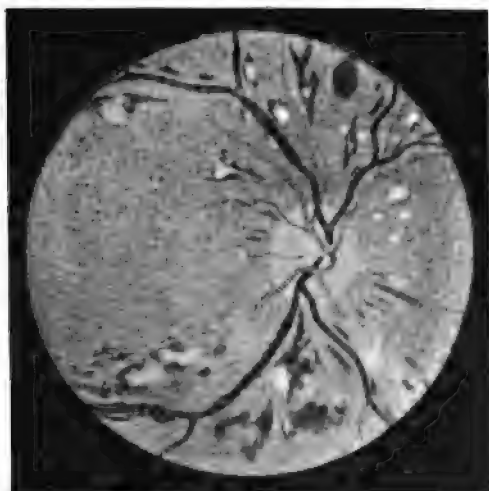


FIG. 154.—Retinal hemorrhages (de Wecker and Masselon).

hemorrhage detaches the internal limiting membrane from the retinal layers, which are not invaded, and occupies the space thus formed. It may break into the vitreous.

**Causes.**—Some of these have already been enumerated.

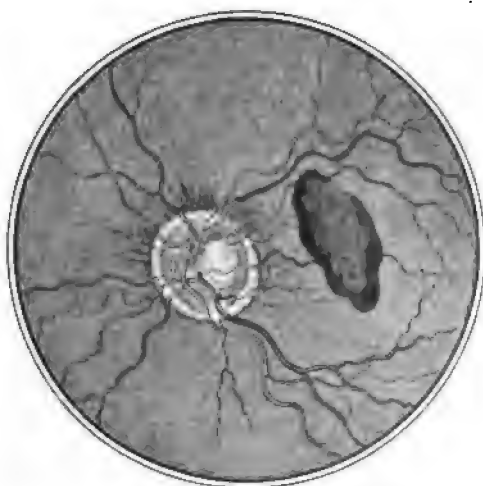


FIG. 155.—Subhyaloid hemorrhage.

The following résumé, based upon the classification of Dimmer, may be added:

(a) Hemorrhages caused by changes in the composition of the blood and the tissues of the blood-vessel walls: Pyemia, septicemia, ulcerating endocarditis; diseases of the liver, spleen, kidney, and atheroma of the vessels; loss of blood (menorrhagia, hematemesis); anemia (simple and pernicious); hemophilia, purpura, and scurvy; diabetes and gout; malaria and recurrent fever.

(b) Hemorrhages caused by disturbances in the circulation: Hypertrophy of the heart and stenosis of the valves; thrombosis of the central vein of the retina, and embolism of the central artery; suffocation, compression of the carotid, and hemorrhages in the newly born; and the menstrual disturbances.

(c) Hemorrhages caused by sudden reduction of the intra-ocular tension—*e. g.*, after iridectomy in glaucoma and by traumatisms. Among the latter may be classed retinal hemorrhages after large cutaneous burns.

(d) Hemorrhages caused by certain toxic agents—*e. g.*, phosphorus, chlorate of potassium, serpent virus.

**Prognosis.**—This depends upon the extent and situation of the hemorrhages. They form an important prognostic guide of the disease which has caused them, and in elderly people may be an indication of future hemorrhages into the brain. Glaucoma, detachment of the retina, and the formation of dense opacities in the vitreous humor may be complications.

**Treatment.**—All use of the eyes must be forbidden. Locally, a weak solution of sulphate of eserine may be employed, especially in elderly people. Internally, the medication must be governed by the probable cause. Frequently, cardiac sedatives, small doses of pilocarpin, and later, alteratives, such as iodid of potassium and bichlorid of mercury, will be required.

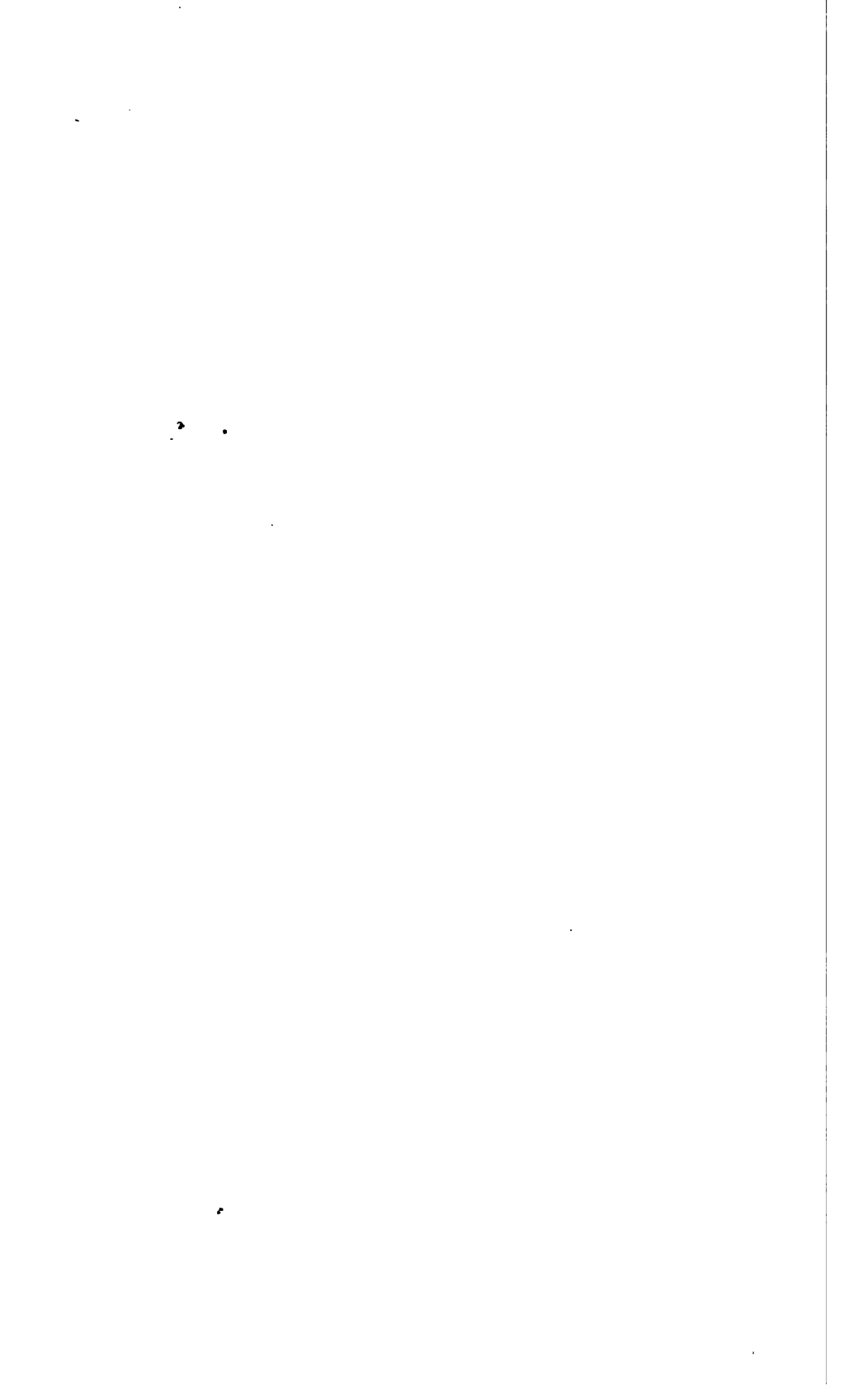
**Changes in the Retinal Vessels and their Walls.**—Certain changes in the retinal vessels due to *vasculitis* and *perivasculitis*, are often seen. These are characterized by the appearance of white stripes along the vessels, or, rather, the vessel-walls become apparent by their conversion into whitish

PLATE IV.



Changes in the fundus in arteriosclerosis.





## Changes in the Retinal Vessels and their Walls 497

tissue, due probably to an infiltration of the adventitia with lymph-corpuscles. This may be so extensive that the entire set of vessels is converted into a series of branching white lines.

Such conditions may be due to various inflammatory diseases of the retina and optic nerve. Alterations in the retinal vessels are also caused by *chronic nephritis* and *general arteriosclerosis*, and present the following ophthalmoscopic appearances :

1. Alterations in the course and caliber of the retinal arteries, manifesting themselves as (*a*) undue tortuosity, which is not significant unless, to quote the words of Mr. Gunn, whose classification is followed, it is associated with other evidence of disease ; (*b*) alterations in the size and breadth of the retinal arteries, presenting, as it were, a beaded appearance.

2. Alterations in the reflections from, and the translucency of, the walls of the retinal arteries, manifesting themselves (*a*) in increased distinctness of the central light-streak on the retinal vessel and an unusually light color of the entire breadth of the artery ; (*b*) loss of translucency, so that it is impossible to see, as is possible in the normal state, through the artery an underlying vein at the point of crossing ; (*c*) positive changes in the arterial walls, consisting of whitish stripes, indicating degeneration of the walls or infiltration of the perivascular lymph-sheaths (*perivasculitis*).

3. Alterations in the course and caliber of the veins, together with signs of mechanical pressure, manifesting themselves (*a*) in undue tortuosity, which, as in the case of the arteries, is not significant except in the presence of other disease ; (*b*) alternate contractions and dilatations ; (*c*) an impeded venous circulation where a diseased artery crosses it. The last is a sign of the utmost importance. Ordinarily, as an artery crosses the vein, as it may be seen by an examination of the normal eye-ground, there is no sign of pressure, and the translucent vein permits a view of the artery beneath it. If the walls of the artery are thickened by disease, then it presses upon the vein, pushes it aside, or directly contracts its caliber, so that beyond the point of crossing there is an

ampulliform dilatation. (*d*) Changes in the venous walls, precisely as they occur in the arteries, so that whitish stripes border the vessel, and are indications of degeneration in its walls. Often associated with this one may see varicosities. (See Plate IV.)

4. Edema of the retina, manifesting itself (*a*) as a grayish opacity, which may be present in the immediate neighborhood of the papilla, or in spots over the eye-ground and along the course of the vessels, looking like a fine gray haze, or in little fluffy islands far out in the periphery.

5. Hemorrhages, manifesting themselves as linear extravasations along the course of the vessels, roundish infiltrations scattered over the fundus, or sometimes in a drop-like form. All these changes have been described by Raehlmann, Friedenwald, Hirschberg, the author, and other observers, and have recently been accurately recorded and classified as given above by Marcus Gunn.

**Angioid Streaks in the Retina** (*Retinal Pigment Striæ*).

—These occur as dark, reddish-brown, sometimes almost black striæ lying beneath the retinal vessels. They give the impression of a system of obliterated vessels, but are caused, according to Ward Holden, by the metamorphosis of hemorrhages, diffused in a linear manner through the deep layers of the retina.

**Aneurysms.**—Aneurysm of the central retinal artery is an extreme rarity. It has been seen as a spindle-shaped sac, pulsating synchronously with the heart. Miliary aneurysms, usually spindle-shaped, have been noted in the small arterial twigs, and may be looked upon as significant of a similar condition of the vessels in other organs, especially the brain. The student should not mistake varicosities in the veins for aneurysms. Arteriovenous aneurysm of the retina has been described as the result of injury (Fuchs).

**Embolism of the Central Artery of the Retina.**—

An embolus may lodge in the central artery of the retina or in one of its branches.

**Symptoms.**—The main branches of the *artery* are thin, and can be followed only a short distance over the edge of the

## Embolism of the Central Artery of the Retina 499

papilla into the retina, and there is a diminution in the number of ramifications. The *veins* are also contracted, and very often they present unequal distention. They may present ampulliform broadening, alternate contractions and swellings, and especially a contraction at the disc, succeeded by broadening in the periphery, where they assume almost their natural breadth. There is no change of diagnostic significance in the color of the blood. Pressure from before backward, so as to increase the intra-ocular tension, causes a regular current to flow through the vessels. This consists of broken cylinders of blood, separated by clear spaces, which move sluggishly along. In the veins, without such pressure, and, it may be, directly after the accident, an *intermittent blood-stream* is often visible. The appearance is not unlike that produced when air is allowed to mix with a fluid in a tube. Occasionally a few hemorrhages are seen along the course of the vessels.

The *papilla* assumes a pallid, grayish-white appearance, owing to the lack of blood in its capillaries. An *opacity in the retina* develops in the form of a grayish-white, *fog-like edema*, sometimes permitting the reddish tint of the normal eye-ground to shine through it, and sometimes being so opaque that it is quite milk-like in its density. This occurs especially in the neighborhood of the papilla and in the macular region, the space between the two often being free, although gradually the areas meet. The opacity comes on within a few hours after the accident, or may be delayed for a day or two. The author has watched it form within twenty minutes after sudden stoppage of the central retinal circulation.

Characteristic of sudden obstruction of the arterial circulation is the formation in the macula lutea (corresponding to the position of the fovea) of a central red spot, which resembles a round hemorrhage in the midst of the milky-white edematous area. It is known as the *cherry-red spot* of the macula lutea, and is caused by the red color of the choroid appearing through the much thinned retina, and changes in the pigment epithelium. As a rare complication, at least in the dark-skinned races, the usual cherry-red spot has been replaced

by a coal-black one. The spot appears at the same time with the opacity in the macula lutea. It is less likely to form where there is a stoppage of a branch of the retinal artery instead of one of the main trunks.

In the course of several weeks there is a gradual subsidence of the retinal edema, the optic disc undergoes atrophy, and the retinal vessels are shrunk or even converted into white cords; if there have been hemorrhages, spots of degeneration appear at their positions, and not infrequently cholesterol crystals and pigment markings may be seen around the disc and in the macula lutea.

Instead of the *main trunk*, a *branch* may receive the embolus, which, in some instances, actually becomes visible to the ophthalmoscope as a yellowish body, but, more frequently, is assumed to be present because at one point of the artery there is a swelling, while beyond it there is complete obliteration of the vessel, or its reduction to an extremely thin caliber. The secondary retinal changes are then confined to the area supplied by this vessel.

Vision is lost with characteristic suddenness. Occasionally, preceding the blindness, there is some uncertainty in vision, or a little headache and giddiness, with flashes of light, representing a species of aura. In obstruction of a branch by an embolus, on the other hand, there may be very good acuity of vision. Indeed, in some instances, even in embolism of the upper branch of the central artery, this has been normal. The presence of a *cilioretinal vessel* may be the means of preserving good acuity of vision.

The *field of vision* varies according to the extent of the blocking of the circulation. In cases where the obstruction is complete, even light perception is absent. If only a branch has been occluded, that portion of the retina which receives its blood-supply from this source will be paralyzed, and the opposite area of the field will be darkened. The presence of a cilioretinal vessel permits, as a rule, an oval portion of the field of vision to remain in the neighborhood of the fixation-point, but, according to C. F. Clark, the evidence is not sufficient to warrant the conclusion that such a vessel is the

## Embolism of the Central Artery of the Retina 501

means of preserving the integrity of the papillomacular region of the retina. Even if the main stem of the artery is obstructed, a portion of the nasal retina may retain its functional activity. An uncommon effect is a central scotoma.

The intra-ocular tension is sometimes raised, sometimes lowered, and sometimes unaffected. The pupil may be large and irresponsive to light if the case is one of complete stoppage of the central artery.<sup>1</sup>

**Causes.**—The most frequent cause of embolism of the central artery of the retina is valvular disease of the heart, especially if complicated by a fresh endocarditis. It also occurs with general arterial sclerosis, aneurysm of the aorta or of the carotid, and with Bright's disease and pregnancy; in a few instances it has been noted with chorea. It may occur at almost any age of life, and has been recorded from the fifteenth to the eightieth year. The accident usually is unilateral, simultaneous embolic plugging of the central artery of each eye being very rare.<sup>2</sup>

**Diagnosis.**—The ophthalmoscopic picture just detailed indicates that there has been an interruption in the retinal circulation, but does not prove that the stoppage has been due to embolism. Similar appearances occur with thrombosis of the central artery from endarteritis, and with hemorrhage into the sheath of the optic nerve, and, according to A. Hugh Thompson, with spasm of the muscular walls of this artery. Thrombosis of the central vein, moreover, may be so situated as to press upon and occlude the lumen of the artery lying beside it. This still further complicates the diagnosis. Certain points of difference will presently be mentioned. Schweigger thinks true embolic plugging of the central artery is exceedingly rare, and that many cases so diagnosticated are due to endarteritis. Emptiness of the arteries is an important sign of embolism. Cloudiness of the retina and the cherry-red spot in

<sup>1</sup> The symptoms which have been described refer to typical cases; a variety of exceptions occur.

<sup>2</sup> In a certain number of cases, although all the ordinary ophthalmoscopic appearances of embolism of the central artery of the retina have been present, it has been impossible to assign a cause.

the macula, according to him, are not early symptoms, but appear a week or more after the lodgement of the embolus.

**Prognosis.**—This is exceedingly unfavorable, and in most instances blindness is the result. Even when temporary improvement occurs, subsequent atrophy of the nerve is likely to ensue. In embolism of a branch the prognosis is more favorable, and, as has been stated, normal central vision may be present. The presence of a cilioretinal vessel improves the prognosis.

**Treatment.**—This does not often prove of avail. In the hope of restoring the circulation by reducing the intra-ocular tension, sclerotomy, iridectomy, and repeated paracentesis of the anterior chamber have been practised, but without success. Vigorous kneading or massage of the eyeball has been recommended, and in some cases has been followed by good results. It should be given a faithful trial. With the massage, inhalations of nitrite of amyl may be given (Gifford).

**Thrombosis of the Retinal Artery.**—This may occur in heart disease, disease of the blood-vessels, and alteration of the composition of the blood. The ophthalmoscopic picture does not differ from that described under embolism, and, according to Welt, the thrombosis may take place from endarterial changes, and independently of them when the blood pressure is reduced and there is a tendency to coagulation of the blood and fatty degeneration of the intima. The symptoms upon which a differential diagnosis may be attempted are stated by Priestley Smith to be: Previous attacks of temporary blindness in the affected eye, a simultaneous attack of temporary blindness in the unaffected eye, and giddiness, faintness, and headaches—symptoms which are absent in embolism.

**Treatment.**—This is the same as that recommended for embolism.

**Thrombosis of the Central Vein.**—This has been observed a number of times as the result of a phlebitis, and also with heart disease when embolism might have been suspected.

In some instances, the appearances have been closely similar to those of embolism; in others they have assumed an inflam-

matory character similar to that described under hemorrhagic retinitis, of which it may be a cause (page 476). Several grades of this condition have been recorded. If, in addition to the ordinary disturbances present in embolism, the ophthalmoscope reveals tortuosity of the vessels, engorgement of veins, and normal or contracted caliber of the arteries, venous pulse, and interrupted venous circulation and retinal hemorrhages, thrombosis of the central vein may be suspected (Angelucci). There may be complete obscuration of the disc, which is hidden by infiltrated retina. Instead of the

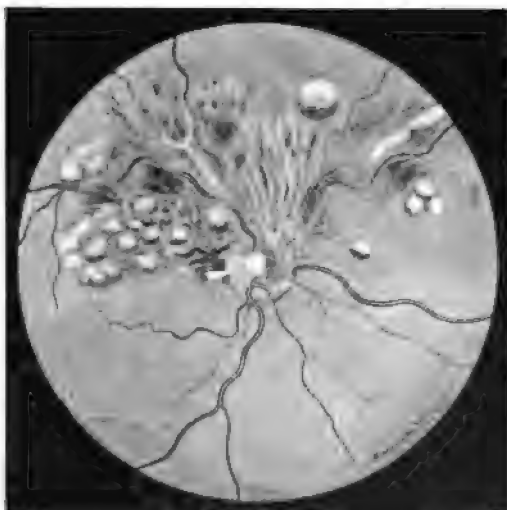


FIG. 156.—Thrombosis of retinal vein.

main trunk, one of its branches may be thrombosed, and the ophthalmoscopic appearances confined to the area which it drains.

**Traumatisms of the Retina.**—Under this general term may be included traumatic anesthesia, traumatic amblyopia, traumatic perforations of the macula lutea, detachment, and rupture. There are no characteristic symptoms common to all varieties, but pain and disturbance of vision, in part due to the direct injury and in part to a transient astigmatism, are likely to be present.



1. *Traumatic anesthesia of the retina* is the name proposed by Leber to describe effects of a blow upon the eye without discoverable ophthalmoscopic changes, but with considerable defect in vision and contraction of the visual field—results, moreover, which may remain unchanged for a long time, or, indeed, never entirely pass away.

The *treatment* is rest and the use of strychnin internally, or by hypodermic medication.

2. *Traumatic amblyopia (commotio retinae; edema of the retina)* is a condition also arising from an injury, especially a blow from a ball, cork, or similar body, and is attended by the following symptoms: Hyperemia of the globe marking the position of contact of the missile; clear media; and gray opalescence of the retina, especially in the macular region, but also around the papilla, which may be somewhat hyperemic. If the retina under the point of contact is visible, this also may exhibit the white infiltration. In addition, several pale yellowish spots, and, occasionally, small hemorrhages, may be present. The vessels are unchanged, or, in some instances, are contracted (arteries) or distended (veins) and pass *over* the gray area. A central scotoma may exist.

An interesting complication is the development of a transitory astigmatism, which helps to reduce the visual acuity.

The gray infiltration forms quickly and is also absorbed with rapidity, usually having subsided at the end of two or three days, although the visual defect may last for longer periods. Decided retinochoroiditis, the result of concussion, may occur, and this fact should be remembered in investigating old cases of choroidal disease presenting themselves with meager history. According to Fuchs, changes in the macula after contusion may be due to inflammatory edema as the result of a low-grade inflammation of the ciliary region.

The *treatment* consists in keeping the pupil dilated with atropin and covering the injured eye with a shade or dark glass, all use of the uninjured organ being forbidden.

3. *Traumatic Perforations of the Macula Lutea*.—Haab has called attention to the fact that a contusion or concussion injury of the eye may cause a round hole in the macula,

## Retinal Changes from the Effect of Sunlight 505

about half the size of the surface of the optic disc, surrounded by a gray ring. The bottom of the hole is of reddish color, with a stippling of white and red. F. M. Ogilvie, who calls the affection "holes in the macula," points out that these perforations are the immediate and direct result of the injury. In his observations these were represented by areas depressed below the level of the surrounding retina, of a deep-red color, and sharply margined by clean-cut edges. In some cases the retina is detached; in others it is not. A central scotoma may be present.

4. *Detachment of the retina* after injury has been mentioned.

*Rupture of the Retina.*—Rupture, uncomplicated by choroidal fissure, the result of injury, is a rare accident, and might be recognized by observing the frayed edges of the tear and seeing the exposed choroidal tissue. Long describes such an occurrence following a fall upon the back of the head.

**Retinal Changes from the Effect of Sunlight (*Solar Retinitis*) and Electric Light (*Electric Retinitis*).**—It has been experimentally proved that retinal changes can be produced in animals' eyes by concentrating upon them the rays of the sun. Clinically, analogous disturbances have been found in the human retina after exposure to intense light, most frequently in those who, with unprotected eyes, have watched an eclipse of the sun. Analogous conditions are caused by intense electric light, especially among those engaged in electric welding.

The *symptoms* are: Persistence of an after-image, or, later, a dark spot in the field of vision (positive scotoma); distortion of objects, and evidences of slight retinitis or retinochoroiditis in the macular region. Thus, there may be a maroon-colored area with a central gray patch, and numerous faintly marked yellowish-white dots.

Decided improvement is not infrequent, but complete recovery is exceptional (Mackay); hence prognosis must be guarded. The scotoma may be permanent (Duane). Degeneration of the papillomacular bundle may occur (E. T. Collins).

The *treatment* is that suited to retinochoroiditis. The preventive treatment consists in wearing suitable colored glasses—yellow glass, or a combination of blue and red, or, as in Sheffield, several layers of ruby glass.

**Glioma of the Retina.**—This is a soft, vascular tumor, made up of small round, deeply staining cells, many of them containing long protoplasmic processes. They form thick mantles of well-preserved cells around the thickened blood-vessels, the cells between the mantles staining poorly and undergoing calcareous degeneration. In many of these neoplasms peculiar *rosettes* have been described by Flexner,



FIG. 157.—Glioma of retina.

Wintersteiner, and others, which are composed of elements resembling the rod and cone visual cells, and for these growths the name *neuro-epithelioma* has been suggested. On the other hand, the Golgi-Cajal silver impregnation method has shown that the majority of the cells are neuroglial in type. Further confirmation of these results may place the growth definitely in this class.

According to the surface of the retina from which the growth takes its origin it has been described by systematic writers as *glioma endophytum* and *glioma exophytum*. In the former, the vitreous chamber is occupied by the growth; in the latter, it lies between the retina and choroid.

The tumor is usually of a light-gray or grayish-red color. It is subject to various degenerative changes—fatty, cheesy, and calcareous—and tends, on the one hand, to invade the orbit, involve the optic nerve, and travel by the way of its sheath to the brain, and, on the other, to pass forward, bursting through the sclerotic and cornea. Recurrence *in loco* after extirpation may occur, and metastases, especially in the cranial



FIG. 158.—Recurrence of glioma, forming the so-called fungus hematodes (from a patient in the Philadelphia Hospital under the care of Dr. Hearn. Photograph by Dr. Pfähler).

and facial bones, and the brain may take place. They also occur, according to F. M. Wilson and E. S. Thomson, in the lymph-glands, parotid, liver, ovaries, kidneys, spleen, lungs, and spine.

Like sarcoma of the choroid, glioma passes through several stages. In the first, there are no signs of irritation, the media are clear, the pupil is dilated, and often the growth produces

a whitish reflection which has given rise to the designation *amaurotic cat's eye*. As the disease progresses symptoms of irritation and increase in the size and tension of the globe become manifest, and the process begins to involve the optic nerve. Finally, the tumor bursts from its bounds, perforates the globe at its corneoscleral junction, grows rapidly, involving the orbit and neighboring temporal regions, and presents a huge vascular mass, to which, in former times, the name *fungus hematodes* was applied.

Glioma of the retina is either congenital or occurs in infancy. It may occur as late as the eleventh year. It is not a common affection. Hereditary predisposition has not been established. Several members of the same family may be affected. One or both eyes are likely to be involved.

**Diagnosis.**—The following conditions, according to E. T. Collins, may be mistaken for glioma: Persistence of the posterior part of the fetal fibrovascular sheath of the lens; masses of tubercle in the choroid; inflammatory or purulent effusion into the vitreous following retinitis or cyclitis, usually with detachment of the retina (see also Pseudoglioma, page 454). Circinate retinitis (white degeneration of the retina), according to de Wecker, has been mistaken for glioma. The author and E. A. Shumway have recorded a case of detachment of the retina with extensive dropsical degeneration of the rod and cone visual cells which exactly simulated glioma. In glioma the anterior chamber is uniformly shallow; in inflammatory exudates into the vitreous the chamber is deepened at its periphery (retraction of iris) and shallow at its center (bulging of pupillary border). Synechiæ are occasionally present in glioma. Tension is usually increased in glioma, but may be minus; rarely, the tension is elevated in pseudoglioma. In case of doubt the eye should be enucleated.

Sarcoma of the choroid is differentiated from glioma by the fact that the former usually occurs at a later period of life, and that in the earlier stages of each affection the ophthalmoscopic findings are different. In glioma the tumor is seen to *involve* the retinal structure, which does not, as in sarcoma, merely act as a covering to the growth.

**Prognosis.**—This is most unfavorable, and if the disease has involved the optic nerve or bursts from its bounds, it is fatal. Spontaneous cure has not been observed, and hence unmolested glioma causes death. Still, numbers of recoveries after proper enucleation are on record, and an opinion must be based on the extent of the disease, the condition of the optic nerve being the most important element in the prognosis. Recurrence is rare after three years of immunity. In a number of fatal cases which have been analyzed (Lawford, Collins) the optic nerve was unaffected in only four. Under unfavorable circumstances recurrence in the orbit occurs, with extension to the brain, and, more rarely, metastasis to a distant organ.

**Treatment.**—Thorough enucleation, with division of the optic nerve as far back as possible, is the only treatment. Any suspicious tissue in the orbit is to be sacrificed. In several instances both eyes have been removed, and recovery after such procedure has been recorded.

**Subretinal Cysticercus.**—This, like the presence of the same parasite in the vitreous, is exceedingly uncommon in this country.

**Symmetric Changes at the Macula Lutea in Infancy.**—This disease, also known as "amaurotic family idiocy," was first described by Waren Tay, and consists of a grayish-white zone about the size of the papilla in each macular region, with a cherry-red spot in the center, closely resembling the appearances seen in embolism of the central artery. Kingdon has thus summarized the general clinical signs: muscular enfeeblement, apathy, mental weakness, and gradual loss of sight. Death occurs in from one to two years. The autopsies show a change in the pyramidal cells of the cortex and degeneration of the cord. According to Sachs, this is an arrest of development. Ward Holden, by Nissl's method, has shown that there is degeneration of the retinal ganglion-cells, which explains the fundus picture.

## CHAPTER XVI.

### DISEASES OF THE OPTIC NERVE.

**Congenital Anomalies.—Opaque or Medullated Nerve-fibers.**—In the normal eye the fibers of the optic nerve cease to be invested with a medullary sheath at the lamina cribrosa, and consequently the axis-cylinders, which are distributed to the retina, are transparent. As an anomalous condition, sometimes bilateral, but more frequently only in one eye, the medullary sheaths reappear at the upper or lower margin of the disc as a dull or glistening bluish-white patch, which extends for a variable distance out into the retina, and ends in a somewhat feathery or fan-shaped margin. Usually the retinal vessels are hidden by the patch, but reappear again on its distal side.

This plaque may be a single one above or below, or it may appear both above and below the disc, more rarely on the nasal side, and very exceptionally, if ever, upon the temporal margin. The size varies from a small expansion to a huge sweep of white tissue, continuous above and below with margins of disc, and taking somewhat the general direction of the vessels, which are wholly or in part concealed. Opaque nerve-fibers of the retina at a considerable distance from the disc have been recorded by Randall, Nettleship, and other observers.

This condition produces no change in vision except an increase in the size of the normal blind spot, and should not be mistaken by the beginner for pathologic lesions—for example, an atrophy of the retina and choroid, or a bank of fatty degeneration as it occurs in retinitis albuminurica.

**Coloboma of the Sheath of the Optic Nerve.**—This congenital anomaly is characterized by an apparent augmentation of the surface of the disc and an excavation of the papilla backward and downward. The periphery is usually bounded

by pigment-massing. There is an unequal division of the retinal vessels, which are first seen as they bend over the margin of the excavation. It is a rare anomaly, and has been mistaken for posterior staphyloma. It depends upon imperfect closure of the fetal fissure.

**Irregularities in the Disc.**—Instead of its usual round or oval shape, the disc may be markedly irregular in outline, one side being occasionally at an apparently lower level than the other, or it may present a gibbous appearance. *Congenital pigmentation of the optic nerve-fibers*, most intense in the position of the physiologic excavation, has occasionally been described.

When the nerve-head fails to fit the choroidal aperture accurately, a space is sometimes formed, usually crescentic, known as a "cone" or "conus" (Loring). This generally is seen at the outer side of the papilla, but also inward, below, and very rarely above. It should not be confused with the cases of atrophy of the choroid seen in myopic eyes, to which the name *posterior staphyloma* is given (page 159), nor with the crescents of choroiditis seen in astigmatic and stretching eyes, in which the scleral ring broadens out into a semiatrophic area of disturbed choroid, usually bounded by an irregular pigment line, and most commonly developed at the temporal side of the disc.

**Shreds of Tissue on the Disc.**—These appear as glistening white patches of tissue, sometimes almost transparent, at other times thicker and more opaque, either completely or partially hiding the vessels (De Beck). Occasionally there is a white membrane more or less completely covering the disc.

Such appearances probably represent remains of the hyaloid artery or of its adventitious coat.

**Hyperemia of the Nerve-head** (*Congestion of the Disc*).—The color of the intra-ocular end of the optic nerve varies considerably, and it is not accurate to describe a nerve-head as congested when it simply is redder than usual.

As Gowers points out, the term *simple congestion* is applicable when the papilla presents a dull red or brick-dust hue, which shades almost imperceptibly, through a blurred margin,



into the general red color of the fundus; when it is more marked in one eye than in the other, the latter serving as a picture for comparison; when at some antecedent examination the same optic disc has presented a more natural color; and when its borders are obscured, but not hidden.

Under other circumstances—and the appearance is a frequent one—the surface of the nerve is covered by a semi-transparent or edematous layer, is unduly injected, and its margins, especially the nasal ones, are veiled by striations composed of fine grayish lines and minute capillaries ordinarily not visible. The perivascular lymph-sheaths at the same time are unduly prominent in the form of white lines along the central vessels, especially the veins. This appearance has received the name “hyperopic disc,” and has also been called “spurious optic neuritis” (Spicer).

**Causes.**—(a) Refractive error, especially hyperopia and hyperopic astigmatism. In this connection, however, the caution of Loring should not be forgotten that the retinal striation and increased vascularity may be due to the presence of unusual amounts of connective tissue and the additional vascularity common to hyperopic eyes. (b) Prolonged exposure to glare and heat. (c) Certain toxic agents presently to be described, and inflammation of the iris, usually of the syphilitic type. (d) Certain disorders of the brain, especially various types of chronic insanity. It is extremely difficult, however, to decide whether congestion is caused by a cerebral condition, because under ordinary circumstances increased vascularity of the papilla is not an index of hyperemia of the cerebral vessels. Focal brain lesion—for example, cerebral embolism—may be associated with hyperemia of the nerve-head.

**Treatment.**—This depends entirely upon the cause. Refractive error should be corrected, if this is the apparent origin of the trouble. Constitutional measures will be required if there is reason to believe that some general cause is at work. Mild cholagogues or saline waters are excellent adjuvants under any circumstances.

**Anemia of the Nerve-head.**—This is not a disease peculiar to the optic nerve, but, like retinal anemia, occurs as

part of a general anemia, or because of obstruction to the central vessels—for example, in embolism.

It is most difficult to interpret the significance of pallor of the papilla. Usually it will require more than mere inspection to decide whether or not a pallid disc is pathologic.

**1. Intra-ocular Optic Neuritis** (*Papillitis, Neuritis, Choked Disc*).—Under the general term *papillitis* are included the various types of inflammation, either with or without the appearances of mechanical congestion, seen at the intra-ocular end of the optic nerve.

**Symptoms.**—Certain symptoms are common to all types of optic neuritis:

**1. Changes in the Nerve-head.**—(a) There are increased redness of the disc and obscuration of its borders, followed by swelling of the papilla, loss of the light-spot, and complete hiding of the margins, the center usually remaining redder than the periphery, which has a grayish tint and shades gradually in a descending slope into the surrounding retina. The swelling increases, assumes a mound shape of mixed grayish color, and finally the form of the disc is lost, and its position can be inferred only by the convergence of the vessels. The height of this swelling is measurable by the table given on page 124 and by the parallax test. White spots and patches are often seen in the elevation sometimes covering the retinal vessel.

**2. Changes in the Vessels.**—The *arteries*, smaller than normal, pursue a moderately straight course and are difficult of recognition, being always partly concealed by the swelling. Occasionally, spontaneous pulsation is visible. The *veins* are dark in color, distended and tortuous, and pass along the slope of the elevation, often dipping into the infiltrated tissue. The light-streak is not lost, at least not where the vessel is clearly visible. The tortuosity of the vessels is sometimes remarkable, and has been compared to the writhing snakes in the *Medusa-head*. The point of emergence and convergence of the vessels may be hidden by the infiltration, so that the center of a *papillitis* seems somewhat destitute of vessels. In some instances thickening of the adventitia of the ves-

sels gives rise to the appearance of white lines along their sides.

3. *Hemorrhages*.—In many cases hemorrhages are found upon the swollen papilla, or in its immediate neighborhood. They are in the form of narrow, flame-shaped extravasations if they lie in the fiber-layer, but may also assume other shapes if situated in a deeper plane. The number varies from a

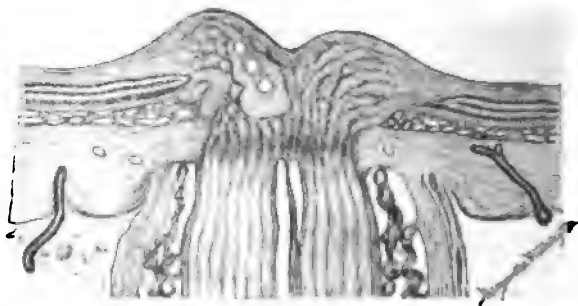
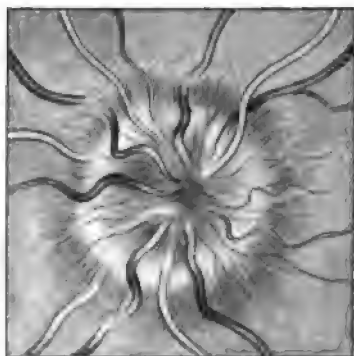


FIG. 159.—Ophthalmoscopic picture of papillitis and semidiagrammatic representation of a longitudinal section of the nerve-head.

single hemorrhage to so many that the swollen nerve-head assumes a hemorrhagic form, or the surrounding retina may be freely occupied by elongated or other-shaped patches of blood.

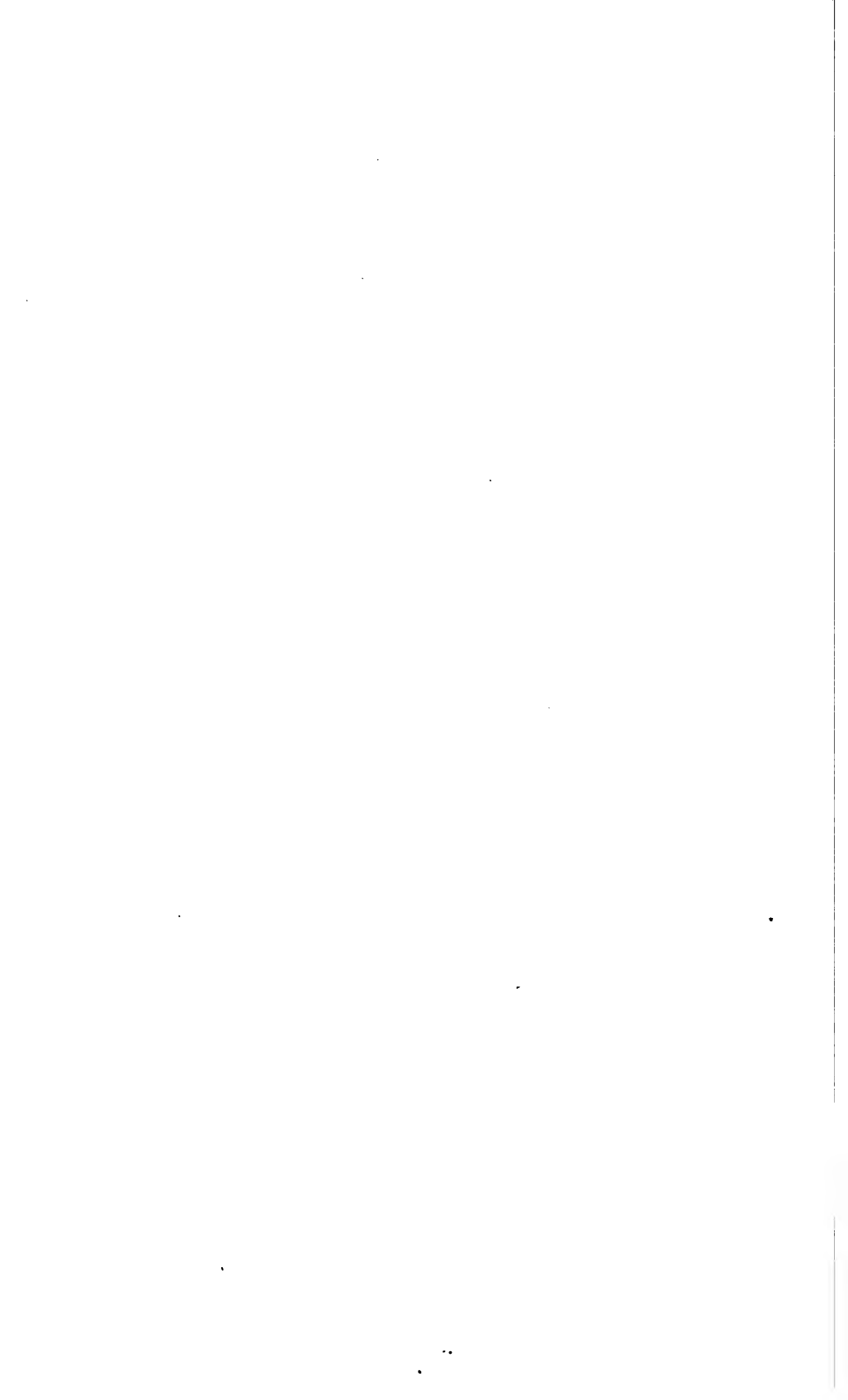
In addition to the ophthalmoscopic changes just detailed, the following points deserve notice :

1. *The vision* in papillitis may be entirely unaffected. This is an important fact, and the mere presence of good central

PLATE V.



The fundus of the right eye of a patient with tumor of the brain, showing optic neuritis, or so-called choked disc.



sight should never be considered cause to omit ophthalmoscopic examination. Usually one eye is more affected than its fellow. Impairment of sight may come on rapidly or slowly. Occasionally vision is lost with great suddenness, but this is rare.

2. *The Field of Vision.*—The field of vision presents for consideration its periphery, which may at first be unaffected and later show irregular and concentric contraction; the increase in the size of the normal blind spot, which becomes correspondingly great in comparison with the amount of swelling; the formation of an abnormal blind spot or scotoma

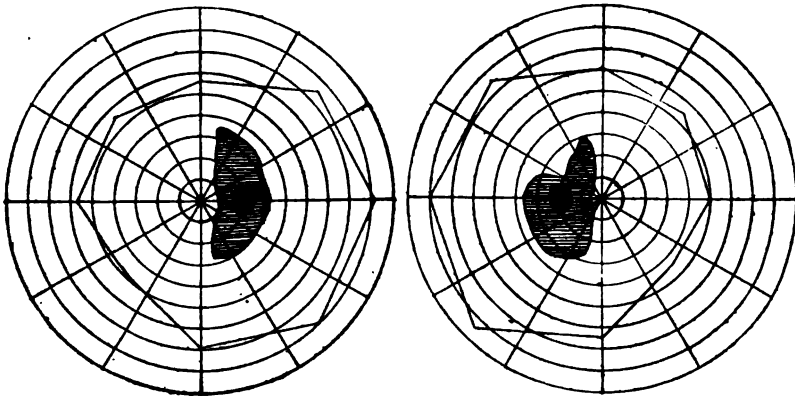


FIG. 160.—Abnormal size of the blind spot in papillitis. The central darker area represents the normal blind spot (reduced about .10) placed there for comparison.

due to involvement of the axial fibers and sometimes to destruction of the ganglion-cells; the absence of half of the visual field (hemianopsia) when the intracranial mischief which may have been the cause of the papillitis is so situated as to produce this phenomenon; and finally, defective color-perception, which may exist when there is no change in central vision and no limitation of the form-field. As in other pathologic conditions, the perception of red and green is usually lost before that of other colors.

3. *External Appearances.*—There are no changes in the exterior of the eye indicative of swelling or inflammation in the

nerve-head. There are no characteristic *pupillary* phenomena. If blindness is complete, the iris is immobile.

**Forms of Intra-ocular Neuritis.**—Papillitis presents itself in different forms, and on this account, in former days, two chief types were described, *choked disc* and *descending neuritis*, to which a third, or rather a different form of the second type, namely, *neuroretinitis*, may be added.

When the symptoms were confined to the intra-ocular end of the optic nerve, and consisted of enormous swelling, giving the impression of mechanical compression, great distention of the retinal veins, and hemorrhages, the name *choked disc* was applied, and is constantly employed at the present day to describe that form of papillitis which is seen with brain-tumor.

When the symptoms consisted of a moderate swelling and no unusual filling of the veins, but, on the other hand, of an exudation which produced discoloration and opacity of the papilla, and which was not sharply limited to it, but passed into the surrounding retina—the term *descending neuritis* was applied.

If an extensive participation of the retina was found, with hemorrhages along the vessels; spots of degeneration in the eye-ground, sometimes collected in a star-shaped figure and analogous to the appearances described under renal retinitis, the condition received the name of *neuroretinitis*.

To avoid confusion of names, as well as to escape unproved theories in pathology, Leber proposed the general term *papillitis*.

In a certain number of instances papillitis is confined to a single eye.

**Diagnosis.**—The diagnosis of papillitis depends upon a direct ophthalmoscopic examination of the inflamed or edematous disc. The method of determining the height of the elevation has been explained.

The student should not mistake the slightly prominent discs that are occasionally seen in hyperopia for papillitis, which should produce, according to Uhthoff, an elevation of at least two-thirds of a millimeter to deserve this name. There may

be a superficial neuritis in hyperopia, and under these circumstances it is difficult at times to decide whether the disc has become inflamed under the influence of an intracranial disease or general trouble, or whether it is congested as the result of eye-strain. For this reason, one of the symptoms of intra-ocular neuritis, namely, redness of the disc, is not a sufficient one upon which to base a diagnosis.

**Course, Complications, and Prognosis.**—There are several grades of papillitis. The first stage usually is not, as might be expected, a simple congestion of the end of the optic nerve, although preceding an actual intra-ocular neuritis there may be very marked tortuosity of the retinal veins, even before any obscuration of the disc itself is observed.

Gowers has divided papillitis into the *first stage*, or the stage of *congestion with edema*, and the *second stage*, or that of *true neuritis*, or *papillitis*.

The most important symptoms of the first stage are indicated by the name which it has received. It presents different appearances, as Gowers has further pointed out, to the direct and indirect examination; in the former, the blurring of the edges of the disc is complete; in the latter it is not complete, and the margins may be seen through the cloudiness.

In the stage of true papillitis, the symptoms before mentioned in reviewing the general symptom-group occur.

The course of the disease is a very variable one. Occasionally swelling of the intra-ocular end of the nerve will come on with great rapidity; in other instances it is slow in its course and lasts for months and even years, with progressive failure of vision.

When the evidences of inflammation and edema begin to subside the veins grow less distended, no new hemorrhages appear, or at least rarely, vessels previously obscured by the swelling begin to reappear, especially in the center of the projection, which becomes depressed. The mixed grayish-red tint becomes more uniformly gray, and grows paler and paler, the borders of the disc begin to be visible, usually first upon the temporal side, until finally all margins again are apparent, at first a little mellowed, while the center is still covered



by the former inflammatory tissue. Finally, the edges of the disc are clear, its color is white and atrophic, and its center becomes apparent. Both sets of vessels are contracted, and may be streaked along their sides with whitish tissue. Areas of retinochoroiditis and elevated patches of degeneration, marking spots of former hemorrhages, are often apparent. Second attacks of neuritis may occur, as in a case observed by the author and A. G. Thomson.

Before a prognosis can be given the cause must be definitely ascertained. If this, as, for instance, in the neuritis which occurs as the result of removable syphilitic deposits, is amenable to treatment, excellent results may be obtained.

**Causes.**—The most frequent cause of papillitis is *tumor of the brain*, being, in the words of C. P. Knapp, its most common general symptom, inasmuch as it occurs in fully 80 per cent. of the cases. The development of papillitis does not necessarily depend upon the size of the growth nor upon its situation, except that tumors of the medulla are said not to originate optic neuritis. According to the researches of Edmunds and Lawford, tumors situated toward the convexity of the brain produce optic neuritis somewhat less frequently than those which develop toward the base. According to the tables prepared by John Weeks, tumor of the corpora quadrigemina gives the highest percentage of papillitis, and next tumors of the parieto-occipital region and of the cerebellum, which yield an almost exactly identical percentage. Growths of the cerebellum may cause a papillitis of an intense type—that is, one having the characteristics to which the term choked disc is applied, but may also originate a more moderate swelling of the nerve-head, somewhat condensed in appearance and comparatively free from undue capillarity. Marked optic neuritis, with swelling, often associated with great increase in capillarity and with hemorrhages, may be due to cerebral neoplasm. All types of morbid growth may originate papillitis—fibroma, sarcoma, glioma, carcinoma, solitary tubercle, and gummas. It also appears with echinococcus cysts, hematoma of the dura mater, and abscess of the brain.

Of the four varieties of meningitis—simple, tubercular, traumatic, and cerebrospinal—tubercular disease of the brain is the most frequent cause of optic neuritis, the percentage varying from 76 to 81 per cent. The appearances of the disc often are those which have been described in connection with descending neuritis and neuroretinitis. When there is direct pressure upon the tracts and chiasm, the swollen papilla has a peculiar gray-white color, without much vascularity.

Other intracranial causes are softening of the brain, hemorrhagic pachymeningitis, cerebritis, hemorrhage (very rare), thrombosis of the cavernous sinus, hydrocephalus, aneurysm, and enlarged pituitary body in acromegaly.

In rare instances myelitis, general paresis, epilepsy, and disseminated sclerosis are accompanied by optic neuritis.

In addition to the intracranial causes of papillitis, this phenomenon may arise from a general infection. To this form Uhthoff gives the name *infectious optic neuritis*. According to this observer, it should be differentiated from those cases which are caused by orbital, intra-ocular, or intracranial lesions, and may be originated by any of the following diseases placed in order of their frequency: Influenza, syphilis, rheumatism, malaria, typhus fever, measles, diphtheria, polyneuritis, small-pox, beri-beri, erysipelas, scarlet fever, tuberculosis, typhoid fever, gonorrhea, and relapsing fever. The neuritis may manifest itself as a papillitis or as a retrobulbar neuritis, and Uhthoff thinks that the optic nerve conditions are most apt to arise during the stage of convalescence and are probably due to the action of toxins and not directly to the micro-organisms. Optic neuritis may also be caused by toxic agents like lead and alcohol, anemia both when this is an essential process and when it is caused by excessive hemorrhage, by disturbances of menstruation, by exposure to cold, by myxedema, by sun-stroke and violent exertion, and by injuries. Optic neuritis followed by atrophy may arise in association with deformities of the skull, and, according to Friedenwald's analysis, the patients for the most part have had oxycephalic or steple-shaped skulls. Blindness without changes in the intra-ocular end of the optic nerve due to cranial deformity has been re-

ported by C. A. Oliver. Papillitis occasionally occurs as a congenital affection in several members of the same family and as an idiopathic disease without evident cause.

Finally, those cases of neuritis arise which depend upon disease of the orbital region—inflammation of its contained tissues, tumors, caries, and periostitis, especially around the optic foramen, purulent disease of the antrum of Highmore and the frontal sinus, and morbid processes of the upper posterior portion of the nose and of the sphenoid and ethmoid bone. In most of these instances, unless both orbits or the sinuses are affected, the papillitis is unilateral, and there are other symptoms around the eye which point to the local condition.

A rare form of optic neuritis is that described in association with persistent dropping of a watery fluid from the nose. Headache, vomiting, unconsciousness, and delirium are present. The fluid has been believed to be identical with the cerebrospinal fluid (Leber) or to be due to nasal disease in the form of small polypi (Nettleship and Priestley Smith).

**Treatment.**—This depends entirely upon the cause of the papillitis. In all syphilitic cases rapid mercurialization should be tried, followed later by the iodids. Indeed, in non-syphilitic cases these remedies are often indicated for their alterative action. In anemia, iron and arsenic should be exhibited; in rheumatism, the salicylates, iodids, and pilocarpin; in menstrual disturbances, measures for the promotion of the catamenial flow, if this has been suppressed. Orbital disease calls for appropriate surgical measures, and in high grades of papillitis, with distention of the optic sheath, several surgeons have exposed this, slit it, and evacuated the contained fluid, in the hope that thus a cause of mechanical compression would be removed. It has also been proposed to trephine the skull and thus relieve the intra-cranial pressure and reduce the engorgement of the nerve-head.

**Significance of Optic Neuritis.**—Double papillitis is highly significant of intracranial disease, especially tumor or basilar meningitis. Indeed, as before stated, it is the most important general symptom of this condition, but it is not a pathogno-

monic sign. The other causes of optic neuritis which have been mentioned must be excluded. Conversely brain-tumor, usually cerebellar, may cause choked disc, with a star-shaped figure of whitish color in the macular region, as was first pointed out by Herman Schmidt and Wegner, exactly simulating the appearances usually considered characteristic of albuminuric retinitis. Although the presence of papillitis is so highly significant of cerebral tumor, of itself it possesses no distinct localizing importance. Usually optic neuritis is bilateral, but in a certain number of instances unilateral, and there seems little doubt that under these conditions the neuritis is more apt to occur on the same side as the tumor. All kinds of tumors and tumors of all sizes may produce papillitis, but it is stated that the neuritis is most frequently absent in tubercular growths and most frequently present with sarcoma, glioma, and cysts.

**Mechanism of Papillitis.**—As is well known, von Graefe at one time sharply distinguished between *descending neuritis* and so-called *choked disc* ("*Stauungs-papille*"). The former term indicated a descent of inflammation from the seat of disease along the optic nerve to its intra-ocular tip. The latter was reserved for a state of the nerve-head supposed to indicate engorgement, edema, and mechanical obstruction, and believed to represent a mechanism and pathology quite different from those ascribed to the former.

Inasmuch as ophthalmoscopically it is frequently impossible to tell one from the other, and as the conditions may be mixed, Hughlings Jackson expressed the opinion that there is one kind of optic neuritis from intracranial disease which may manifest itself under different appearances, sometimes with and sometimes without "swelling of the disc."

Numerous theories have been propounded to explain the *mechanism of papillitis*. Von Graefe believed that choked disc was due to a venous stasis occasioned by obstruction to the return of venous blood from the cavernous sinus. This theory ceased to be tenable when Sesemann demonstrated the anastomosis between the ophthalmic and the anterior facial veins. The *lymph-space theory* advocated by Schmidt-Rimpler and

Manz ascribed to the dropsy of the intersheath space of the optic nerve, which is caused by the increased subarachnoid fluid being forced into this situation under the influence of elevated intracranial pressure, a mechanical or compressing action, or to the fluid which found its way into the lymphatic spaces of the optic nerve, an action causing edema, congestion, and inflammation. Parinaud contends that in choked disc there is an extension of the interstitial edema of the brain tissue through the optic nerve to its intra-ocular end. The *inflammatory theory*, with various modifications, assumes, as Leber suggested and Deutschmann afterward experimentally showed, that papillitis is not a product of edema but an inflammatory affection, the fluid which distends the sheath of the nerve possessing an irritative quality; or, in other words, that the subarachnoid fluid is infected by products from the intracranial disease or lesion which is the prime cause of the trouble. Elschnig believes that the ophthalmoscopic picture to which the term choked disc is applicable is indicative of an inflammation of the optic papilla characterized by a high degree of inflammatory swelling of all its tissues. Merz, based upon experimental evidence, declares that increased intracranial tension alone is sufficient to produce choked disc. It is only necessary that this tension shall be maintained uninterruptedly for a certain time. In general terms microscopic examination would seem to indicate that in a certain number of cases papillitis represents a true *engorgement edema*, and that the evidence of inflammation is lacking, while in other cases the inflammatory signs are decided. When engorgement edema is the marked feature, the ophthalmoscope reveals the typical picture of choked disc. When, on the other hand, the inflammatory condition predominates, the elevation of the disc is less marked and the process is apt to extend to the retina, where exudates and hemorrhages are visible; in other words, an *inflammatory optic neuritis* is present.

**Pathology.**—Sections of choked disc examined with the microscope reveal the following lesions: Edema and swelling of the nerve-head, blood extravasations, swelling and varicosities of the nerve-fibers, and slight cellular exudation along

the thickened and dilated vessels. In the interstitial form of neuritis the inflammation begins in the sheath and septa, with the formation, in addition to the edema, of an exudate rich in cells, which subsequently organizes. There follow thickening of the interfascicular septa, increase of the nuclei, and degeneration and atrophy of the nerve-fibers from pressure. In some cases degeneration of the ganglion-cells of the retina is evident, depending upon the fact that an arterial branch supplying that particular area has been occluded. Such degenerative areas may give rise to scotomas or sector-like defects in the visual field. An ampulliform dilatation of the optic-nerve sheath posterior to the eyeball is found in a certain number of cases, and in addition to distention of the intervaginal space there may be an infiltration of small cells in the sheath.

The many varieties of papillitis which occur independently of intracranial disease indicate that the optic papilla is a structure prone to be inflamed.

**2. Optic-nerve Atrophy.**—Under the general term *atrophy of the optic nerve* are included the various types of degeneration and shrinking of the fibers of the optic nerve, usually described under the subdivisions *primary*, *secondary*, *consecutive* (*neuritic* or *postpapillitic*), and *retinal* and *choroiditic atrophy*. The last are really forms of consecutive atrophy.

**Symptoms.**—Certain general symptoms are common to optic-nerve atrophy, although these are subject to variations according to the clinical types.

*1. Changes in the Nerve-head.*—(a) *Alterations of the Normal Color of the Disc.*—The color of the disc varies from a slight gray pallor to a pure gray, greenish-gray, or entirely white hue. Many intermediate forms of discoloration occur; thus there may be a commingling of gray and red, producing the so-called “gray-red disc,” and often there is a decided greenish tinge, rarely a blue one.

Much experience is required before deciding that change of color in the nerve-head is pathologic, and a careful consideration of the age of the patient, the general complexion, the probable richness of the blood, the extent of the physiologic

cup, and the character of the illumination must be regarded. Grayness of the optic nerve will not always be apparent to ordinary methods of examination, especially when present in the deeper layers of the disc, but when examined by means of properly regulated illumination, and through a lens which neutralizes any existing error of refraction, this becomes manifest, and the appearance is then described as "a disc with superficial capillarity, but with gray deeper layers."

It is important to employ both the direct and indirect methods of examination, and the concave and plane ophthalmoscopic mirror.

(b) *Alteration in the Center of the Disc.*—Sinking of the surface of the disc, varying from a slight depression to a complete excavation (page 405), occurs according to the degree of degeneration which the nerve-fibers have experienced. The shape of the excavation depends somewhat upon that of the normal physiologic cup, if this has been present. At the bottom of the atrophic excavation the mottling of the lamina cribrosa is very distinct in some cases of atrophy; in others it is not apparent.

(c) *Alterations of the Margins of the Disc and of the Scleral Ring.*—In complete atrophy the margin of the optic disc is unusually distinct. In the atrophy which follows a neuritis or retinitis, however, the margins are often slightly veiled for a long time.

Undue broadening of the scleral ring indicates shrinking of the disc. Even in the early stages of spinal atrophies the disc may be surrounded by a broad scleral ring, which, taken into consideration with alteration in the color of the papilla and contraction of the color-field (especially red and green), affords diagnostic aid in the study of gray degeneration of the optic nerve.

2. *Changes in the Vessels.*—In simple atrophy, while there may be narrowing of the vessels, this is not always the case, and certainly not in the manner seen in consecutive atrophies. Sometimes the arteries are narrowed and the veins unchanged.

In neuritic (consecutive) atrophy the arteries are much contracted and the veins in contrast are larger than usual,

often retaining some of the tortuosity which was so marked a feature during the papillitic stage. By the contraction of the tissue these, too, may later become narrowed. Development of white tissue along the course of the vessels, due to thickening of the perivascular lymph-sheath, is common in this form of atrophy.

In retinitic and choroiditic atrophy there is marked contraction of both veins and arteries, which at the same time are diminished in number.

3. *Changes in the Surrounding Eye-ground.*—The presence of alterations in the general fundus depends entirely upon the cause of the atrophy. In simple gray and white atrophy such signs are absent; but in postpapillitic and retinitic atrophy, spots of degeneration, marking the places of former hemorrhages, and patches of pigment-heaping, are commonly seen.

In addition to these ophthalmoscopic changes the following symptoms occur:

1. *Change in Central Vision.*—This varies from a slight depreciation to blindness, and, if the atrophy is bilateral, is usually more marked upon one side than upon the other. In every case, where this is possible, especially in early cases or cases of doubtful atrophy, a neutralization of any exciting refractive error should be made before deciding the degree of depreciation of central sight.

2. *Change in the Field of Vision for Form (White).*—The following changes occur: Concentric contraction; very irregular limitations presenting large reentering angles (peripheral scotomas); quadrant-shaped defects; complete loss of one-half of the visual field (hemianopsia); and an abnormal blind spot in the center of the field (central scotoma).

The field of vision, concentric restriction being most common, does not give evidence of the cause of the atrophy, although it may afford information of the localization of the defect; thus, an affection of the macular fibers will produce a central scotoma. In spinal atrophy the limitation more frequently begins at the outer side than in other situations.

3. *Change in the Field of Vision for Colors.*—There is always



a defect in color vision. Usually there is first contraction of the green field, then of the red, and afterward of the blue and the yellow field. The confusion and complete loss of central color vision occurs in the same way. Exceptions to this statement are found, and the perception of red may first feel the influence of atrophy.

Generally the contraction of the color-field is much greater than that of the form-field (white) (compare page 420). Central vision may be good, the form-field but slightly or not at all affected, and yet the green and the red fields may be con-

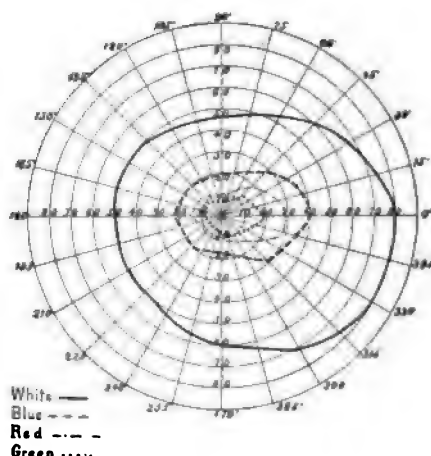


FIG. 161.—Field of vision of the right eye in a case of optic nerve atrophy. The form-field is slightly contracted, the color-fields markedly restricted (compare figure 41, page 94).

siderably contracted. Hence the importance of combining all these examinations before deciding whether discoloration of the papilla is pathologic or not.

4. *Changes in the Pupil.*—The relations of the pupil to the action of light depend upon the degree of atrophy. Hence, in the majority of cases there is more or less perfect paralytic mydriasis, and when the atrophy is complete, the pupil is dilated and the iris motionless. Even when the pupil fails to contract under the influence of light thrown upon the retina, it may do so in the act of convergence.

If the atrophy is confined to one side, no reaction will occur when the light falls upon the corresponding retina, but instant contraction takes place when this is directed upon the retina of the opposite (unaffected) side. In spinal disease (tabetic atrophy) certain changes in the pupil are seen, partly characteristic of this affection (page 67).

**Varieties of Optic-nerve Atrophy.**—1. *Primary Atrophy* (*Sometimes called Gray, Progressive, Spinal, or Tabetic Atrophy*).—The color of the disc is gray or white; sometimes it has a greenish or bluish tint; the discoloration is associated with translucency, and the stippling of the lamina is evident; the excavation, if it exists, is complete and saucer-like; the vessels either are smaller than normal, especially the arteries, or they are unaffected in size; the edge of the disc is sharply marked, and the scleral ring clean cut all around. These symptoms describe the fully formed atrophy.

In the earlier stages of the degeneration, according to Norris, the discs are of a dull-red tint, their capillarity is superficial, and the deeper layers, in the neighborhood of the lamina cribrosa, are gray and wanting in circulation. There is often sufficient haze of the retinal fibers to veil the scleral ring. Later the nerves become pallid, are somewhat woolly superficially, and are surrounded on all sides by broad and sharply cut scleral rings. The larger retinal arteries and veins do not at this stage present any appreciable change in their caliber or appearance. Both eyes usually are affected, one showing a further advance of the degenerative process than its fellow.

2. *Secondary Atrophy.*—The color of the disc may be gray and assumes a tint not greatly dissimilar from the atrophy which has just been described. In other instances the color is more decidedly white. Both sets of vessels may be contracted, usually the veins being less affected than the arteries. In a certain number of cases of secondary atrophy it is probable that preceding the degenerative stage there is a transient congestion of the discs; certainly this is true in those cases where there has been a retro-ocular neuritis.

3. *Consecutive Atrophy.*—(a) *Postpapillitic Atrophy.*—The

color of the disc is very gray or white, sometimes with a decidedly greenish tinge or even a blue tint. It is noticeable, however, that the translucency present in the primary form of atrophy is absent, and the stippling of the lamina cribrosa is not visible, owing to the existence of a non-transparent tissue which covers it. The borders of the disc are slightly veiled, and the perivascular lymph-sheaths are thickened. The arteries are contracted, the veins frequently exhibiting distinct tortuosity. Retinochoroidal changes are often evident.

(b) *Retinitic and Choroiditic Atrophy*.—This is in the form of atrophy of the nerve to which reference has already been made, and which follows violent forms of retinitis and choroiditis. The color of the disc is characterized by having a distinctly yellowish tinge, being somewhat waxy in appearance; its borders are not sharply marked, and the vessels are narrowed, often to a great degree.

**Causes.**—In addition to the forms of atrophy which follow inflammation of the nerve *postpapillitic* inflammation of the choroid and retina (*choroiditic* and *retinitic atrophy*), embolism and thrombosis of the central artery and central vein of the retina (*embolic atrophy*), the etiology of those examples that are gathered under the general terms *primary* and *secondary* atrophy require mention.

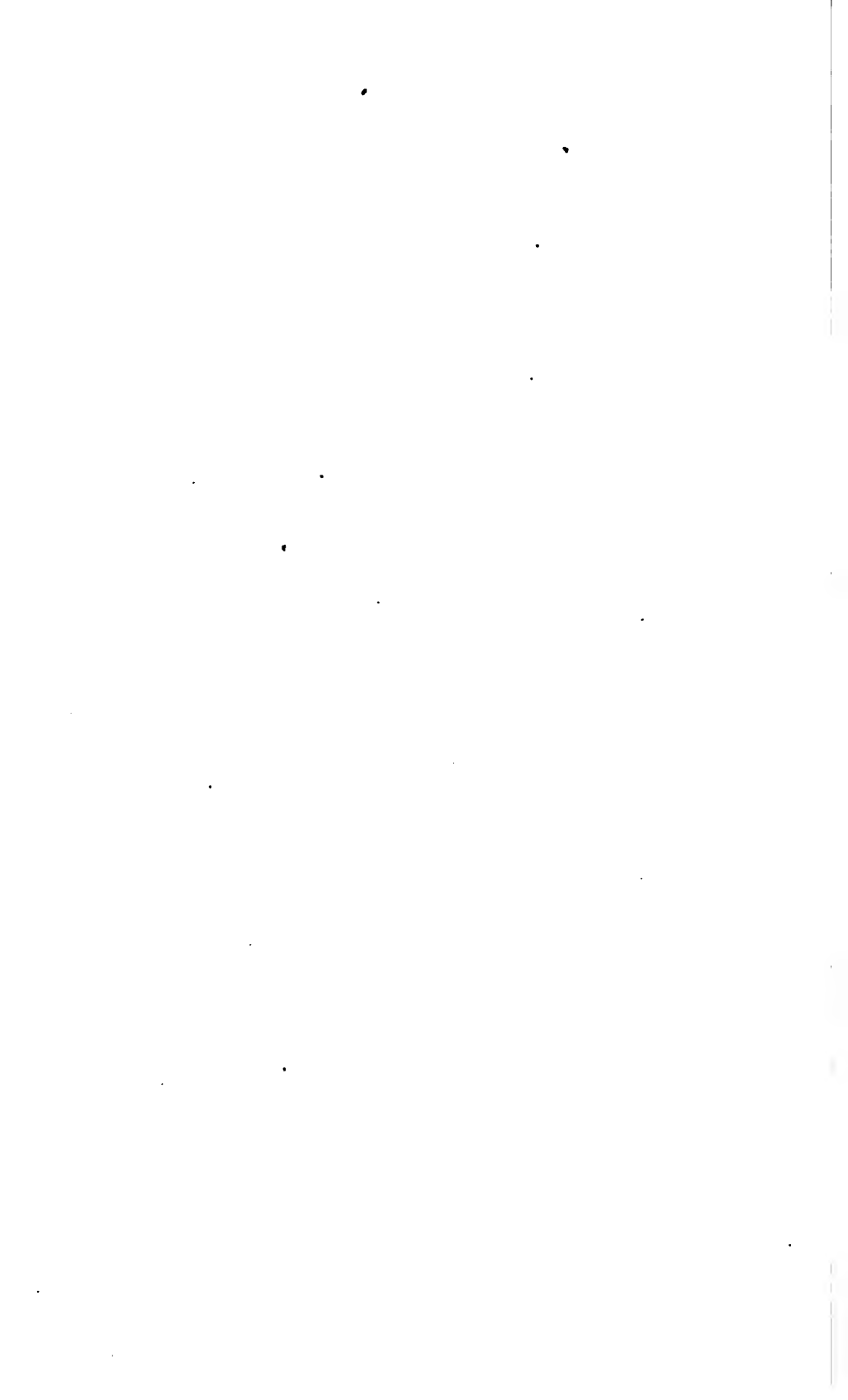
*Gray degeneration* of the optic nerve occurs, in the great majority of instances, under the influence of diseases of the spinal cord, and especially of locomotor ataxia. It is frequent in general paralysis of the insane and insular sclerosis, but less common in lateral sclerosis. There is some difference of opinion in regard to the frequency of optic-nerve atrophy in locomotor ataxia, but an average of a number of observations gives 33.7 per cent. of atrophies. In most instances it begins in the preataxic stage. Optic-nerve atrophy has also been seen with Friedreich's ataxia, amyotrophic lateral sclerosis, chronic myelitis, paralysis agitans, spastic spinal palsy, and bulbar palsy.

*Primary atrophy* has been ascribed to the influence of cold, imperfect nutrition, disturbed menstruation, and venereal ex-

PLATE VI.



Primary atrophy of the optic nerve.



cesses. There is no doubt that in certain instances it is due to chronic malaria, diabetes, syphilis, and the toxic action of certain drugs. Its association with deformities of the skull has been described (page 519).

*Hereditary Optic-nerve Atrophy.*—A remarkable type of optic-nerve atrophy, first systematically described by Leber, is hereditary, and may appear for a number of generations almost exclusively in the male members of the family, although it is often transmitted through the female line. The disease usually begins between the eighteenth and twenty-third year, but has been observed as early as the fifth year and delayed as late as the forty-third year. According to Norris, there are three stages of the affection: (1) Stage of edema and congestion of the disc; (2) stage of gray discoloration of the nerve-head; and (3) stage of pronounced atrophy. Central scotomas are commonly present. Gould suggests "homeo-chronous hereditary optic nerve atrophy" as a suitable name for the disease.

Finally, there are instances of optic-nerve atrophy which can be ascribed to no very definite cause.

*Secondary atrophy* appears under the influence of compression of the optic tract and the optic fibers—for instance, by bulging of the lateral ventricles, pressure of a tumor, exostosis, or aneurysm (S. Weir Mitchell) upon the chiasm. It is also said to occur with meningitis without preceding neuritis. Any compression around the optic foramen is likely to produce secondary atrophy by direct injury to the fibers of the optic nerve, just as in other instances it may produce a neuritis.

Blows on the head may produce optic-nerve atrophy. This has been noted after injuries in the neighborhood of the supra-orbital foramen, and is due to fracture of the orbital plate or to periostitis.

Finally, there is a series of atrophies resulting from an inflammation of the axis of the nerve back of the ball.

**Pathology.**—In simple degeneration as it occurs in tabes of the cord the nerve-fibers lose their medullary sheaths and are converted into fine fibrillæ, between which are numerous fatty granular cells; no true inflammatory process appears. Later

all nervous elements may disappear. Ward Holden has suggested that tabetic atrophy of the optic nerve depends upon a disease and disappearance of the retinal ganglion-cells. In postneuritic atrophy there is considerable new-formed connective tissue in the nerve-head and trunk, through which run the thickened vessels; the sheaths of the nerve-fibers degenerate, break down into fine drops, and the nerve-fibers become varicose and either shrink or disappear altogether. The septa become much thickened, and in advanced cases the nerve becomes a narrow, purely connective-tissue cord.

**Diagnosis.**—The diagnosis of optic-nerve atrophy rests upon a consideration of the symptoms already detailed. The student is particularly warned not to mistake the pallor of age for the pallor of disease; not to mistake a large physiologic cup, with its margin shelving toward the temporal border of the disc, for an atrophy confined to half of the optic papilla; not to mistake a posterior staphyloma, which may surround the entire disc, for an atrophy; and not to mistake small patches of retained marrow-sheath for atrophic changes.

Not every gray disc, with an unusually marked scleral ring, is indicative of atrophy, and it is only when these appearances accord with the other manifestations of beginning degeneration that the diagnosis of incipient atrophy is justified.

The differential points between a chronic glaucoma and an optic-nerve atrophy have been described (page 420), and also the relation of light-sense to optic-nerve atrophy.

**Course and Prognosis.**—The course of optic-nerve atrophy is always a slow one, lasting for months and it may be years, depending to a certain extent upon the original cause of the atrophy.

The prognosis is unfavorable in primary or, as it is sometimes called, progressive atrophy, the tendency being to a gradual deterioration of sight with shrinkage of the field of vision, until complete blindness is the result. The prognosis of a consecutive atrophy depends entirely upon the amount of damage which is likely to ensue from the shrinking which follows during the subsidence of the neuritis. In the forms

of atrophy which follow an inflammation of the axis of the nerve the prognosis is better.

In making up a prognosis it is necessary to examine not only central vision, but also the field of vision. Sometimes the former remains stationary while the latter progressively contracts, and under these circumstances false information would be given unless both examinations were undertaken.

**Treatment.**—This depends upon the cause. If syphilis is suspected, the usual remedies are indicated, especially mercuric chlorid; but mercury is useless in advanced cases, even in syphilitics. The most generally valuable remedy is strychnin, administered in full doses, preferably by the hypodermic method. It may be enforced by nitroglycerin. Other remedies, according to the cause, are iodid of potassium, nitrate of silver, phosphorus, arsenic, iron, santalin, lactate of zinc, hypodermics of antipyrin (Valude), and injections of organic liquids. Galvanism has been advised, particularly voltaic alternatives (Riggs; L. W. Fox), and good results have been reported. In the author's experience galvanism has proved unavailing in true atrophy of the optic nerve. Indeed, of the remedies mentioned, none has afforded more satisfactory results than those usually employed—viz., mercury (in suitable cases), the alteratives, strychnin and nitroglycerin, and the value of these is limited. In a few instances suspension is said to have been followed by improvement of vision in tabetic atrophy.

**Orbital Optic Neuritis** (*Retrobular Neuritis; Central Amblyopia*).—In contradistinction to the optic neuritis which is specially localized at the intra-ocular end of the nerve, an inflammation occurs in the orbital part of the optic nerve, which is called *orbital optic neuritis*, or *retrobular neuritis*. It appears in an *acute* and a *chronic* type.

1. *Acute Retrobulbar Neuritis*.—The symptoms of this affection are the following: Obscuration of vision, beginning always in the center of the visual field, and rapidly progressing in from one to eight days to complete or nearly complete blindness; at first negative ophthalmoscopic appearances, later blurring of the margins of the disc, hyperemia of its sur-



face, and sometimes, in severe cases, diminished caliber of the retinal arteries and fullness and pulsation of the retinal veins; distinct pain on movement of the eyeball, or when the globe is pressed backward into the orbit.

The affection appears to depend upon an interstitial neuritis, most severe in the optical canal, and at first chiefly located in the papillomacular tract, from which it may extend, however, until the whole diameter of the nerve is involved. If the process is unchecked, necessarily secondary degeneration of the nerve-fibers takes place. There is also degeneration in the ganglion-cells of the macula.

**Cause.**—The determining cause of the disease is the presence in the blood of an infecting agent existing in association with some disease—for example, rheumatism, gout, syphilis, influenza, diabetes, or scarlet fever; or coming directly from a focus of infection in the mucous membrane of the nose, the ethmoid cells, or the sphenoid sinus; or arising as the direct result of an inflammatory process in the orbit—*e. g.*, cellulitis, or in the optic canal—for example, periostitis, gummatous deposits, etc. The disease has also been attributed to certain toxic agents, such as alcohol, lead, etc.; to menstrual disturbances, especially sudden suppression of the menses, and to overwork and prolonged eye-strain. A certain number of cases exist for which no cause can be ascertained. Nettleship divides cases of retrobulbar neuritis into two groups: the *idiopathic*, in which the disease starts in the nerve itself, and *symptomatic*, in which it is communicated to the nerve by the surrounding tissues.

A similar ocular disease is at times part of the symptomatology of an insular sclerosis and acute or subacute myelitis, and is then of most serious prognostic import.

The *course* of the disease may be rapid or fulminant, as it is called. It is sometimes bilateral, but more frequently unilateral, or a long interval may occur between the affection of the first and second eye. Relapses may occur, and the affection may alternate between the two eyes. As pointed out by Mr. Marcus Gunn, there is marked analogy between retro-ocular inflammation of the optic canal and paralysis of the facial

nerve (Bell's palsy) when its trunk is involved in its tortuous course through the wall of the skull. Indeed, as the author has shown, retrobulbar inflammation may be preceded by an attack of peripheral facial palsy, either upon the same or the opposite side.

Although the *prognosis* must always be guarded, in the majority of instances the tendency is to recovery, and, under careful treatment, to perfect recovery. In severe cases, permanent pallor of all or part of the optic nerve, defective central vision for colors, central scotoma, and contraction of the peripheral field may remain. The fact that retrobulbar neuritis may indicate the future onset of disseminated sclerosis should not be forgotten. There is also a variety of the disease due to exposure, menstrual disturbances, or rheumatism, in which the same symptoms appear as those previously described, but all of a milder type, and all more amenable to treatment.<sup>1</sup>

**Treatment.**—In so far as possible the patient must be removed from the influence of the cause. If the affection has occurred during the course of an acute infectious disease, the treatment of this particular malady is indicated. Under other circumstances the best results follow pilocarpin sweats, full doses of salicylic acid, the free use of mercury, the iodids, and counterirritation on the temple. If there is an affection of the accessory sinuses, this must receive suitable treatment.

2. *Chronic Retrobulbar Neuritis (Tobacco Amblyopia ; Toxic Amblyopia).*—The clinical symptoms of this affection are as follows: Diminution of sight, associated with foggiess in the center of the field of vision, unimproved by glasses; reduced acuity of vision, which varies from  $\frac{3}{8}$  to counting fingers; negative ophthalmoscopic appearances or pallor of the temporal half or of a quadrant-shaped portion of the papilla; normal peripheral boundaries of the field of vision; symmetric central color scotomas, especially for red and green, usually oval in shape, stretching from the fixing-point to the blind spot, and rarely passing much to the nasal side of the former;

<sup>1</sup> For excellent discussions of retro-ocular neuritis the reader is referred to the *Transactions of the Ophthalmological Society of the United Kingdom*, 1897, vol. xvii., to Nettleship's article in the *London Ophth. Hosp. Reports*, xv., 1, p. 1.

defective light-sense. The scotoma, which is the most important of the symptoms, represents a red-green blind area, and commonly the extent of green-blindness is greater than that of red, which, in its turn, may be surrounded by an area of imperfect color-sense. Sometimes its beginning is a small, easily overlooked scotoma exactly over the fixing-point (Groenouw). When the typical egg-shaped scotoma is developed, the process may cease, or there may be a stage of progression characterized by an increase in the size of the color defect, usually above, until it meets the limit of the red field; that is, the scotoma has "broken through." In severe cases there may be scotoma for blue and yellow. Finally,

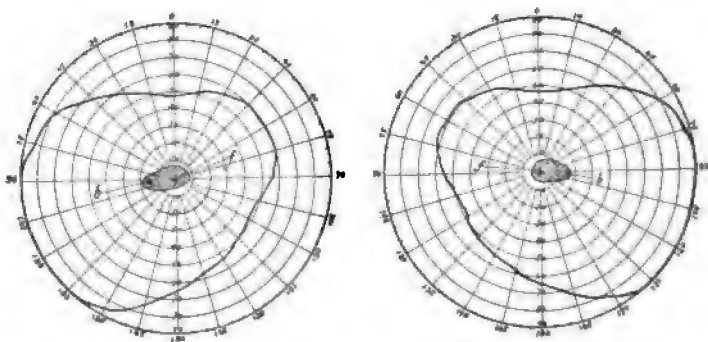


FIG. 162.—Central scotoma from a case of tobacco amblyopia: *f*, Fixation; *b*, blind spot.

small absolute defects may be found, and in neglected cases, or in those not typically toxic, the entire scotoma may become absolute.

**Causes.**—The various drugs and toxic substances which may be responsible for the clinical symptoms which have just been detailed are tobacco and alcohol, either singly or combined, stramonium, cannabis indica, chloroform, chloral, opium, bisulphid of carbon, nitrobenzol, arsenic, lead, iodoform, and the toxin of diabetes. Of the substances mentioned, tobacco is the one most often responsible for this affection, but as the users of tobacco are also usually consumers of alcohol, it is difficult to separate the etiologic influence of these two drugs, and hence the name *intoxication* or *toxic-amblyopia* is used to

describe a central amblyopia which may be due to either of these substances or to their combined influence. Although usually bilateral, a few instances have been recorded in which the symmetric development of tobacco amblyopia has been delayed. It is rare before the thirty-fifth year.

The pathologic lesion which causes this form of amblyopia, according to Uhthoff and other observers, is an interstitial inflammation of the *papillomacular* fibers of the optic nerve. These fibers, traced by means of their degeneration, consist of a bundle shaped like a triangle near the eye, with its base in the lower and outer part of the nerve, and its apex at the central vessels. Gradually it passes to the center of the nerve,

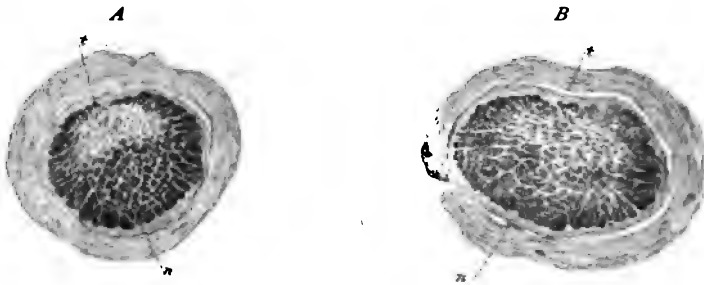


FIG. 163.—Sections of the right optic nerve in a case of toxic amblyopia, showing degeneration of the papillomacular bundle (Weigert's stain): *A*, Transverse section of the optic nerve, 13 mm. behind the globe; *B*, Transverse section of the optic nerve in the region of the optic foramen.

which it reaches in the optic canal. Finally it can be followed into the chiasm and tracts. Nuel and others believe that central toxic scotoma is not caused primarily by a neuritis of the macular bundle, but represents a disease of the macula lutea, causing degeneration of its cells, and that the optic nerve changes are secondary to destruction of the nerve-cells in the macula. Recent investigations of Birch-Hirschfeld lead him to doubt that the process depends upon a primary interstitial inflammation of the optic nerve. He believes that there is a primary involvement of the nervous elements of the nerve and retina, with an accompanying proliferation of the glia and increase in the connective tissue.

**Course and Prognosis.**—The course is, as its name indi-

cates, a chronic one, but the prognosis of the tobacco and alcohol cases is good, provided the patients present themselves at an early enough stage for treatment.

**Treatment.**—This consists in total abstinence from the use of tobacco and alcohol, and in the earlier stages this alone will be sufficient to bring about a cure. Later the best remedy is strychnin, which, as in other instances of optic-nerve disease, should be pushed to its full physiologic limit. In order to help in the absorption of inflammatory products, iodid of potassium may be given; certainly if there is any reason to suspect syphilis. In addition to this regulation of diet, rest and an occasional free diaphoresis are valuable adjuvants. Temporary improvement occurs under the influence of inhalations of nitrite of amyl, and the circulation of the optic nerve may be stimulated by the exhibition of digitalis and nuxvomica.

Necessarily, if some poison other than alcohol or tobacco is active, the patient must be removed from its influence.

**Injury of the Optic Nerve.**—This may occur by the entrance of a foreign body into the orbit, like the end of a sharp stick, or from a fracture involving the bony wall of the orbit or base of the skull. Atrophy of the optic nerve is the result.

**Tumors of the Optic Nerve.**—These are of rare occurrence, according to Finlay, about 100 cases having been recorded, and include fibroma, sarcoma, glioma, endothelioma, gumma, tubercle, and myxoma. Finlay's researches have recently been extended by J. F. Bullar and C. Devereux Marshall.

The *symptoms* are: Exophthalmos, the eye being pushed downward and forward, the motion of the globe being unaffected; and defective vision, which is an early manifestation. The growth is slow and painless, but sometimes a suppurative keratitis may result. The ophthalmoscope reveals distended veins, edema and inflammation of the papilla, followed later by white atrophy and shrinking of the vessels.

**Treatment.**—Finlay's analysis shows that in 11 instances the tumor has been excised without removal of the eyeball,

with subsequent loss of the globe in 4 cases, but in most cases enucleation has been necessary, the nerve being severed far back so as to include the entire growth. Exenteration of the orbit has been performed in 4 cases. Among 68 operations, according to Finlay, there were 11 relapses and 11 deaths. He advises operative interference as soon as the diagnosis is made.

**Hyaline Bodies (Drusen) in the Papilla.**—This affec-



FIG. 164.—Microscopic section of a nerve-head containing hyaline bodies (from a photomicrograph).

tion is characterized by the formation in the optic papilla of small excrescences or globular formations, which are sometimes described as colloid masses. The bodies are variously shaped, chiefly roundish, of a yellowish-white or bluish-gray color, forming a mulberry-like appearance and presenting a striking ophthalmoscopic picture. They may occur at any age of life, sometimes in association with choroidoretinitis, optic neuritis, and optic-nerve atrophy, but also in eyes free from other pathologic changes and with perfectly normal vision. Two

views have been maintained in regard to the origin of the drusen: (1) That they are hyaline excrescences of the lamina vitrea of the choroid which become imbedded in the head of the optic nerve, and (2) that they have nothing in common with the choroidal excrescences, but are a special pathologic process confined to a small portion of the optic nerve. The microscopic studies of the author indicate that the latter view is the more nearly correct of the two. The exact nature of the material thus deposited has not been determined. One investigation by Hirschberg and Cirincione indicates that the bodies are amorphous and organic, and their composition appeared most to resemble that of elastin. They may undergo calcification, like the cheesy nodules in the lung.

## CHAPTER XVII.

### AMBLYOPIA, AMAUROSIS, AND DISTURBANCES OF VISION WITHOUT OPHTHALMOSCOPIC CHANGES.

AMBLYOPIA and amaurosis are terms which signify *dimness of vision*, the former being used to describe *obscurity of sight*, and the latter the more advanced condition of *loss of vision*. Although these terms are usually applied to cases in which no changes are visible in the eye, this limitation is not strictly followed, and eyes blinded by inflammatory disease are sometimes described as *amaurotic*.<sup>1</sup>

Modern methods of examination have greatly lessened the number of conditions to which the older writers applied the words "amblyopia" and "amaurosis." Amblyopia is a symptom and describes the defective vision from which the patient suffers. This may be due to functional disturbance or to disease of the visual apparatus (retina, optic nerve, or visual centers), and may be unassociated with changes in the eye-ground; or there may be atrophy of the optic nerve.

Amblyopia may be congenital or acquired; temporary or permanent; symmetric or non-symmetric.

**Congenital Amblyopia.**—This name is applied to instances of defective vision for the most part uncomplicated with fundus lesions, although sometimes the papilla is discolored and there is a scotoma, either small and absolute, or larger and for colors alone. The faulty vision has always existed, and often high grades of refractive error, especially hyperopia and astigmatism, are present, and clear images have never been focused upon the retina. Correction of the optical error fails to produce normal vision or even nearly normal

<sup>1</sup> The term amaurosis is also applied to certain cases of blindness in young children dependent upon hereditary influence, syphilis, tubercular disease, and meningitis. The eye-grounds may or may not be diseased.



vision; the retinal images continue to be defective. In young patients an eye of this character may occasionally be trained to more nearly perfect vision after a proper correction of the refractive error, and this attempt should always be made.<sup>1</sup>

Defective vision, attributed to lack of use (*amblyopia ex anopsia*, *argamblyopia*, according to Gould), may occur on account of obstruction to the rays of light falling upon the retina—*e. g.*, congenital corneal opacities, congenital cataract, and impervious persisting pupillary membrane; or in an eye which from earliest infancy has squinted, and has, therefore, not been concerned in the visual act (compare with page 597). The amblyopia of a squinting eye may disappear if the seeing eye becomes blind or is removed, as in a remarkable case reported by W. B. Johnson.

Gould maintains that certain cases of amblyopia which have been attributed to disuse are really due to a low grade of choroidoretinitis affecting the macular region, brought into existence by an irritating stimulus with which a long-continued ametropia has supplied this area.

In this category of amblyopias are also placed certain congenital defects of structure—*e. g.*, coloboma of the iris and deficient development of the entire eye (microphthalmos). Retinal hemorrhages in the newly born explain some cases. Usually one eye is affected; if both are amblyopic, nystagmus commonly is present. Squint may be developed when a single eye is amblyopic.<sup>2</sup>

**Congenital Amblyopia for Colors** (*Color-blindness*).—Congenital disturbance of the color-sense has been found in

<sup>1</sup> A form of amblyopia has been described by Martin and called *astigmatic amblyopia*, dependent upon an imperfect development of the functions of the finer anatomic elements of the retina. It has been attributed to the fact that at the time of the education of the sense of sight, owing to astigmatism the retina has been asymmetrically stimulated, and consequently there has been asymmetry of visual acuity.

<sup>2</sup> A persistent cramp of the lid, such as occurs in children, unrelieved for weeks at a time, may produce blindness, noticed when the eyes are finally opened, temporary in its character, with normal ophthalmoscopic appearances. In other cases the loss of vision, however, is permanent, with gross changes in the eye-ground. This condition has been referred to under blepharospasm (page 212).

about 3 per cent. of the examinations made for this purpose, but it is extremely rare in women (0.2 per cent.). Both eyes, except in rare instances, are affected, and a distinct hereditary tendency has been noted in many instances. In other respects the functions of eyes which are "color-blind" are normal, and the cause of the condition has not been determined.

Derangements of the perception of colors have been divided into two varieties: the one characterized by an absence of the power to perceive colors, or *achromatopsia*; and the other characterized by difficulty in distinguishing colors, or *dyschromatopsia*. The former condition, or color-blindness, is rarely *total* as a congenital defect (a condition which is not uncommon as the result of pathologic changes in the optic nerve, etc.); generally it is *partial*—i. e., one or more of the fundamental colors are not recognized.

According to Helmholtz's theory, three classes of *partial color-blindness* exist—blue-blindness (also called violet-blindness), green-blindness, and red-blindness.

A person afflicted with *blue-blindness* (*yellow-blue blindness*, according to Hering) sees only red and green. He usually confounds blue with green, purple with red, orange with yellow, and violet with yellow-green or gray.

A person afflicted with *green-blindness* (*red-green blindness*, according to Hering), to quote from Thomson, confounds light green with dark red, does not recognize a dark-green letter on black, but recognizes well a red one on the same background. Preyer states that the most frequent confusions are: brown with dark green, red with green, red with orange, red with yellow, red-yellow with green-yellow, bluish-green with purple.

A person afflicted with *red-blindness* (*red-green blindness*, according to Hering), again to quote from Thomson, confounds light-red colors with dark green, and cannot see a dark-red square on a black ground. According to Preyer, the most frequent confusions are: red with dark green, yellow with green, green with bright red, bluish-green with gray, orange with greenish-yellow or with red, orange with golden yellow, with grass-green, or with red, purple with blue.

Red- and green-blindness are the most usual manifestations of color-blindness; the other type—blue-blindness—is not common. Knies has described congenital violet-blindness; red and purple are not distinguished from each other, both being called red.

In the second variety, or imperfection in the color-sense (reduced color-sense), the individual may correctly recognize brightly marked colors, but becomes confused in colors closely allied and in the various shades. To him violet and blue and orange and red are difficult distinctions. Dyschromatopsia should be distinguished from partial color-blindness (Landolt). The methods of detecting color-blindness have been described on page 71. Congenital color-blindness must not be confounded with the various disturbances of the color-sense which result from diseases of the optic nerve and retina or with those which are seen in hysteria. No treatment is of avail.

**Reflex Amblyopia.**—Certain cases of partial or complete loss of vision have been vaguely attributed to irritations in distant portions of the body—for instance, the presence of parasites in the intestinal canal. In many of these instances, however, a proper investigation has shown that other causes have been active in producing the defective sight.

A number of well-established cases are on record in which an irritation through the branches of the fifth nerve has produced an amblyopia, chiefly with disease of the teeth. At all events, in any case of amblyopia unattended with ophthalmoscopic changes, and not readily classified in any of the well-recognized groups, a thorough examination of the teeth is advisable.

**Traumatic Amblyopia.**—This may occur after severe injuries to the head, especially in the occipital region; bruises along the course of the spinal cord after a railroad injury; and blows upon the brow in the region of the supra-orbital nerve.

In some of the cases there is either a fracture across the optic canal, a hemorrhage into the intracranial cavity, or some disorganization of the brain contents, followed by secondary

changes in the optic nerve. In other instances no ophthalmoscopic changes are discovered, and the defective vision may be temporary in character, or there may be effusion or hemorrhage into the intersheath of the optic nerve. Amblyopia after railroad injuries is sometimes enormously exaggerated by patients in the hope of securing damages.

The *treatment*, provided there is no gross lesion, such as atrophy, hemorrhage, or an edema of the retina (*commotio retinae*), is rest until there is proper recovery from the injury, and the use of strychnin, especially hypodermically.

Amblyopia and amaurosis occur under the influence of disease and the toxic action of certain drugs, due either to a direct effect upon the retina, to an influence upon the visual centers, or to some change, perhaps of vasomotor origin, affecting the blood-supply of these structures.

In this category may be noticed :

**1. Uremic Amblyopia, or Amaurosis.**—This is almost always caused by scarlet fever or pregnancy. In scarlet fever it appears with albuminuria in the stage of desquamation, and is bilateral, the blindness in many cases being absolute and often associated with brain symptoms: convulsions, vomiting, stupor, coma, and hemiplegia. In spite of the total blindness a characteristic symptom is the preservation of the pupillary reactions.

The ophthalmoscope picture may be negative, or there is a slight neuritis, or a little woolliness of the surface of the optic disc or delicate edema of retina. The *prognosis*, as far as vision is concerned, is good.

The *treatment* does not differ from that which is applicable to the disease which produced it.

**2. Glycosuric Amblyopia.**—In addition to the affections of vision already described in connection with diabetes (paresis of accommodation, premature presbyopia, cataract, and retinal hemorrhages), there occurs an amblyopia in this disease in which the visual field is sometimes peripherally intact, sometimes peripherally restricted, and occasionally hemianopic, but in which there is a central color scotoma. This amblyopia may be the only symptom of diabetes, and in any unexplained

case of amblyopia the urine should be examined for sugar, a practice which is necessary if color scotomas are found, even if a history of the abuse of tobacco is obtainable.

The prognosis is unfavorable, and the treatment, which should include the usual measures suited to diabetics, is not very efficacious.

**3. Malarial Amblyopia.**—In addition to the amblyopia in malarial cachexia with lesions apparent in the fundus, are those cases, without such lesions, due to a special action of the malarial poison upon the optic nerve and the retina. These appear in the form of a transient loss of vision, or as complete blindness, lasting from several hours to some days or even months. The affection disappears under antiperiodic treatment. In most of the instances ophthalmoscopic findings are negative, or the descriptions are included in vague terms applied to the retina and optic nerve—"congestion," "hyperemia," and "redder than normal." The affection may be unilateral or bilateral.

**4. Amblyopia from Loss of Blood.**—Loss of sight often follows hemorrhage, more frequently when this is spontaneous than after a traumatism, and is said to be most complete after hemorrhage from the stomach. It also may follow epistaxis, hemoptysis, urethral and intestinal hemorrhage.

Two very different results may ensue: Either a temporary blindness, owing to the impoverished blood-supply of the visual centers or retina, or a permanent loss of sight and atrophy of the optic nerve. Ward Holden has shown that the amblyopia following hemorrhage is due to degeneration of the retinal ganglion-cells, together with their long processes, which make up the centripetal fibers of the optic nerve.

The ophthalmoscopic appearances vary from a slight pallor to complete atrophic whiteness of the papilla, with contraction of the arteries. The lesions in the unfavorable cases usually do not appear until a week or more after the hemorrhage has taken place. Neuritis and hemorrhages into the retina may also arise. The prognosis is most favorable in uterine cases.

The *treatment* consists in the use of iron, arsenic, and strychnin, complete rest, and an easily assimilated diet.<sup>1</sup>

**Amblyopia from the Abuse of Drugs.**—A certain number of toxic agents (lead, tobacco, alcohol, etc.) produce an axial neuritis or a degeneration and destruction of the retinal ganglion-cells, with great loss of vision, and these have been described under the general term *orbital optic neuritis* (page 531).

Amblyopia, more or less complete, may arise under the toxic influence of nitrate of silver, mercury, bisulphid of carbon, nitrobenzol, salicylic acid, cannabis indica, stramonium, malefern, iodoform, osmic acid, chloral, and lead. The last agent may produce a neuritis, but also an amblyopia without ophthalmoscopic changes. It is usually transient, occurs in acute cases, and has been compared by Gowers to the temporary amaurosis of uremia.

The loss of vision which occurs under the influence of quinin deserves special mention. It usually is called *quinin amblyopia*, or *amaurosis*. Although in most instances quinin blindness follows the ingestion of a large quantity of the drug, occasionally the symptoms appear with moderate doses. The author has seen 12 grains produce decided temporary amblyopia in a susceptible and neurotic woman.

The characteristic clinical features of quinin amaurosis are total blindness subsequent to taking large doses of the drug, extreme pallor of the optic discs, marked diminution of the retinal blood-vessels in number and caliber, and contraction of the field of vision. Other symptoms which have been noted are: diminution of the color- and light-sense, dilated pupils, and immobile iris during the blind stage, and occasionally anesthesia of the cornea. Usually the effect of quinin upon the ear is manifested by deafness and tinnitus.

<sup>1</sup> In addition to the amblyopias without ophthalmoscopic changes, seen with the diseases already mentioned, others, less commonly observed, could be included. For example, sudden blindness with preserved pupillary reaction and without ophthalmoscopic changes has been noted with whooping-cough, and is probably due to central edema between the corpora quadrigemina and occipital lobes.

The restoration of central vision may be perfect or incomplete. The contracted field of vision gradually widens out, but does not regain its normal limits. The disc may remain pallid and quite atrophic looking years after the poisoning; in other instances it resumes its normal tint. In one case (Gruening) a cherry-colored spot was noted in the macula, in another a scotoma in the visual field. Occasionally the blindness is permanent.

The first effect of the toxic influence of quinin is to lessen, through spasm of the vessels, the blood-supply of the retina and optic nerve, and later, as the author has experimentally shown in dogs, permanent optic-nerve atrophy ensues. De Bono believes that quinin intoxicates the protoplasmic elements of the retina, acting as a depressant poison on the rods and cones; but Ward Holden has shown, and his results have been fully confirmed by Drualt and Birch-Hirschfeld, that the effect of the diminished blood-supply is a degeneration of the ganglion-cells and nerve-fibers of the retina, followed by an ascending degeneration of the optic nerve. It is possible that there may be a direct action of the quinin on the nervous elements.

The *treatment*, in addition to the discontinuance of the drug, consists in the administration of nitrate of amyl, which will cause temporary improvement and the exhibition of strychnin and digitalis.

**Hysteric Amblyopia.**—Hysteric blindness usually occurs in young girls and women; but both males and females may be affected. The loss of vision is complete, and almost always monolateral. Usually the pupil reacts promptly to light when the sound eye is covered, but in some cases there is complete temporary loss of the light reaction. The ophthalmoscopic appearances are normal. Quite commonly it is possible to prove by the usual tests that the supposed blind eye really sees.

In addition to monocular blindness there is a large group of cases in which achromatopsia or dyschromatopsia, contraction of the field of vision, and hemianesthesia constitute the symptoms. Sometimes, instead of simple contraction of

the field of vision, there is hemianopsia; rarely scotoma. The defect of vision may occur in the form of *crossed amblyopia*—i. e., complete or partial blindness on the same side as the hemianesthesia, and associated with some deficiency of acuity of vision upon the opposite side.

Not only may there be partial or complete color-blindness in hysteria, but also more or less reversal of the order of the colors as they normally appear. In a series of cases studied by Dr. John K. Mitchell and the author, this phenomenon was well shown. No other ocular manifestations were present.

Hysteria produces many other remarkable functional disturbances of the eye—monocular diplopia, ptosis, blepharospasm, conjugate deviation of the eyes, and the great symptom-group gathered under the term “retinal asthenopia”—which do not properly belong to this category.

The *prognosis* of these cases in the main is good, although the blindness may last for long periods of time.

The *treatment* consists of measures calculated to improve the condition of the patient—massage, rest, electricity, and tonics.

**Pretended Amblyopia (*Malingering*).**—For the purpose of escaping irksome duties—for example, in the army—or to excite sympathy patients will occasionally pretend to be blind in one eye. In order to detect the deception many plans have been originated. Two methods will be described:

**1. The Diplopia Test.**—This is performed in the same manner as the ordinary examinations of the external ocular muscles with prisms. The subject is seated before a lighted candle at 20 feet distance, and a 7° prism placed before the admittedly sound eye. If, now, superimposed double images are acknowledged, there is binocular vision, and the fraud is detected. The examiner may vary the test by placing the prism before the supposed blind eye, either base up or base down.

**2. Harlans' Test.**—This is an extremely useful and simple device, and is performed as follows: Place an ordinary trial-frame upon the subject's face and put before the admittedly



sound eye a high convex glass (+ 16 D), and before the eye which is claimed to be blind a plain glass or a weak concave spheric (− 25 D), which will not interfere with vision. If letters placed at a distance of 6 meters are read, the act of reading must have been done by the eye which was claimed to be sightless, inasmuch as vision at that distance with the other eye is excluded by the presence of the high convex lens. The test may be further elaborated by covering the pretended blind eye and requesting the patient to read the letters; if he is unable to do so, the fraud is at once exposed.

If a malingerer claims to be blind in both eyes, these tests will not avail, and he can be detected by placing a careful watch over him. The fact that the pupil contracts on exposure to light does not prove that there is sight in the eye, because, as Swanzy points out, a lesion in the center of vision, or in the course of the fibers connecting this center with the corpora quadrigemina, producing absolute blindness, would still permit a perfect reaction of the pupil to light. Priestley Smith and E. Jackson suggest the following test for feigned *binocular blindness*: Place a lighted candle in front of the subject; now hold a 6° prism, base out, before one eye; if both eyes see, the one behind the prism will move inward, and on removing the prism, will move outward, the other eye remaining fixed.

**Night-blindness** (*Functional Night-blindness; often incorrectly termed Hemeralopia, but properly Nyctalopia*).—It has already been pointed out that night-blindness is one of the early symptoms of pigmentary degeneration of the retina. In the present condition, however, there are no retinal lesions.

It is a functional complaint, consisting in a diminished sensibility or imperfect adaptation power of the retina (Treitel), due, apparently, to exposure of the eye to strong light, together with a debilitated and often scorbutic state of the system. It affects residents in tropical countries, often soldiers and sailors, and has been occasionally observed in large schools, usually in the early spring or summer (Nettleship, Snell). It prevails as an endemic in certain countries, especially in Russia during the Lenten fasts. Adamück disputes

the influence of fasts and attributes the disease to miasmatic parasites.

Krienes divides the affection into *acute essential nyctalopia* (hemeralopia) and *chronic nyctalopia*, and he gives the following syllabus of symptoms: Decided dread of light, abnormal width of the pupil in the dark, depreciation of the central quantitative color-sense, particularly the blue sense in daylight, narrowing of the color-fields in daylight, particularly the blue field, abnormal shrinking of the visual field for white and colors in increasing twilight. Other not absolutely constant symptoms are loss of visual acuity by daylight, shrinking of the visual field for white in daylight, retinal tire field, paresis of accommodation, epithelial xerosis, erythropsia, and xanthopsia (see also page 266).

**Treatment.**—This includes the administration of iron, quinin, strychnin, and cod-liver oil, according to the indications. Dark-colored glasses should be worn. If scurvy is present, the diet and remedies suited to this condition should be prescribed.

**Day-blindness** (*Often incorrectly termed Nyctalopia, but properly named Hemeralopia*).—This is an affection, or rather a symptom, as the name implies, characterized by the fact that its subjects see better on dull days and in the dark than in a bright light. The visual field is not concentrically contracted.

This symptom occurs with the condition described by Arlt as *retinitis nyctalopia*, and with orbital optic neuritis of the chronic type (tobacco amblyopia, page 533). It also occurs in other affections of the optic nerve and in some diseases of the retina. The same condition may be present with certain congenital anomalies—albinism, coloboma of the iris, and iridemia. It also occurs as an idiopathic affection, and may develop in those who have long been excluded from the light. It may also be congenital, and may be associated with an amblyopia of like origin.

A tonic *treatment* should be tried and the retina gradually educated to sustain bright light.

**Snow-blindness.**—As this ordinarily is seen in northern regions, it is an affection of the conjunctiva. There are burn-

ing pain, photophobia, blepharospasm, hyperemia of the conjunctiva, and chemosis. In severe cases there may be ulceration of the cornea. The pupils are small, and there is congestion of the retina. The visual acuity may be unaffected, or it may be distinctly lessened, especially if corneal complication or a scotoma coexists. The dazzling of the snow may cause restriction of the field of vision, scotoma, and night-blindness,<sup>1</sup> but when the sun shines, the heat reflected from the surface of the snow produces an erythema of the conjunctiva. If the sunshine is absent, a mechanical cause is found in small flying particles of snow and ice (A. Berlin). Prolonged exposure to powerful electric light may produce analogous symptoms—*electric ophthalmia*. Those much engaged in work with the Röntgen rays often suffer from decided conjunctival hyperemia or positive conjunctivitis.

**Erythropsia, or Red Vision.**—Colored vision in glaucoma (iridescent vision), in the form of variously tinted halos about the lamp-lights, has been described, and patients with blind eyes occasionally complain of being conscious of colored lights, owing probably to some irritation of the visual centers.

Erythropsia in most instances has been noted after cataract extraction. Visual acuity is not affected, but everything appears of a red or violet color. An uncommon phenomenon is *blue vision* or *kyanopsia*. Bromid of potassium is indicated, and is said to ameliorate these symptoms. *Green-vision* has been noted after cataract extraction and corneal wound, and in connection with diseases of the optic nerve and retina—for example, with tabetic optic-nerve atrophy (H. W. Dodd).

**Micropsia** and **megalopsia** have been described in connection with syphilitic retinitis. They may appear as functional disorders in hysteric cases.

<sup>1</sup> The opposite condition, day-blindness, has been reported.

## CHAPTER XVIII.

### AMBLYOPIA OF THE VISUAL FIELD, SCOTOMAS, AND HEMIANOPSIA.

THE importance of perimetric measurements in the study of various forms of ocular disease, especially in glaucoma and in affections of the retina, choroid, and optic nerve, has been noted (for the methods of examination consult Chapter II.). There remain to be considered certain conditions in which a defect in the field of vision constitutes one of the most prominent symptoms.

#### **1. Partial Fugacious Amaurosis** (*"Flimmer-scotom"*).

—The symptoms are: A sense of vertigo; a positive darkening of the field of vision of each eye, beginning at the center and widening out in a vibratory movement until it overspreads the field, with corresponding sinking of the central acuity of sight; and cessation of the amaurosis with the onset of headache and vomiting. It may then be a prodrome of hemi-crania, but is also seen without it, and may occur in syphilitic subjects. The condition probably depends upon circulatory disturbances in the occipital lobes.

The *treatment* is directed toward the headache, the partial amaurosis being exceedingly temporary in character, and includes the measures suited to migraine. Syphilis calls for the usual remedies.

#### **2. Amblyopia of the Visual Field** (*Anæsthesia Retinæ*).

—This functional disturbance as part of a general neurosis has been described on page 466. Because of the peculiar changes in the visual field many authors prefer the name "amblyopia of the visual field" to that of "anesthesia of the retina."

Somewhat analogous restrictions of the visual field are seen after injuries, and with *traumatic anesthesia* of the retina; in the latter condition the element of hysteria cannot always be eliminated.

**3. Scotomas.**—Any lesion which blots out the function of a portion of the retina produces a corresponding blind area in the field of vision, or a scotoma—for example, a hemorrhage, a patch of retinochoroiditis in the macular region, or spots of disseminated choroiditis in the periphery of the eye-ground. Papillitis causes an enlargement of the natural blind spot (consult Fig. 160), and retrobulbar neuritis a central scotoma. The different forms which scotomas assume are described on page 96. The scotomas associated with chronic glaucoma have been described on page 409. Unilateral scotomas may occur in hysteria, with menstrual disorders, in partial embolism of the central artery of the retina, and with

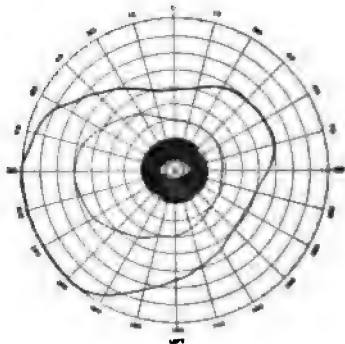


FIG. 165.—Ring-shaped scotoma from a case of interstitial neuritis.

disease of the macular cortical center. *Ring-shaped* scotomas have attracted much attention. Ordinarily they are to be explained by the presence of chorioretinitis. According to Burnett, circumscribed neuritis of the intermediate bundles of the optic nerve may explain some cases. They are seen in cases of chorioretinitis, pigmentary degeneration of the retina, and sometimes in interstitial neuritis and glaucomatous atrophy of the optic nerve. Under the last-named condition the author has suggested they may be due to degeneration of annular areas of ganglion-cells.

In addition to these diseases certain affections of the optic nerve are accompanied by a scotoma.

Following the classification of Jensen, these may be described as:<sup>1</sup>

(a) **Central Amblyopia with Scotoma** (*Toxic Amblyopia*).

—This affection has been described on page 533.

(b) **Stationary Optic Atrophy, with Scotoma**.—This is characterized by a scotoma, similar to the one which occurs with toxic amblyopia, but much more decided. There are marked diminution of central vision, a depreciation of the color-sense, and ophthalmoscopically the appearances of optic-nerve atrophy. The process is stationary, and vision does not improve under treatment. Jensen finds this affection exclusively in men before their thirty-fourth year. It has a hereditary tendency, and is said to be caused by exhaustion and lack of sleep. Sometimes no cause can be demonstrated. Preceding the atrophy there may be slight neuritis.

In the cases of *hereditary atrophy* of the optic nerve recorded by W. F. Norris, the ophthalmoscopic changes commenced with a stage of cloudy swelling of the disc and passed on to a gradual death of the nerve. The disease began with a central scotoma, first for color, but gradually this became complete. Both the males and females of the family were affected (see also page 529).

(c) **Progressive Optic Atrophy with Scotoma**.—This includes the class of cases in which the optic-nerve atrophy of spinal disease (tabes dorsalis and disseminated sclerosis) is associated with a scotoma. The scotoma is central and shaped like the one in tobacco amblyopia, but as the disease progresses the peripheral field contracts, and finally it becomes difficult to detect the central defect. It is not common to find a central scotoma in tabetic atrophy of the optic nerve; it is more frequent in insular sclerosis.

(d) **Optic Neuritis with Scotoma**.—An unusual symptom of intra-ocular neuritis caused by meningitis is a central scotoma, either relative or absolute. The student should not

<sup>1</sup> A translation by Dr. G. A. Berry of a lengthy abstract of Jensen's article on "Diseases of the Eye Accompanied by a Central Scotoma" appears in the *Ophthalmic Review*, January, 1891.

confuse this with an enlargement of the natural blind spot due to the inflammatory swelling of the nerve-head.

As has already been pointed out, the cause of central scotoma in orbital optic neuritis (toxic amblyopia) is degeneration of the papillomacular bundle in the optic nerve or a destruction of the macular ganglion-cells. Whether a partial affection of the optic nerve will explain all cases of central scotoma remains to be seen, and Jensen suggests that a common central cause may be active.

**Obscuration of One-half of the Visual Field, or Hemianopsia.**<sup>1</sup>—In diseases of the eye—*e. g.*, glaucoma—one-half of the visual field may be wanting, and also in cases of optic-nerve atrophy and neuritis, even when unconnected with disease of the visual pathway. These cases, however, are not included in the present account.

Hemianopsia is that defect of vision characterized by an obscuration, usually in each eye, of one-half of the field, which occurs under the influence of a lesion situated at the optic chiasm, in the optic tract, in the visual radiations, or at their ultimate destination in the brain (occipital lobe).

**Visual Tract.**—The visual tract, or visual conduction paths, may briefly be described as follows:

The retina is a highly evolved structure, which, from the histologic standpoint, may be divided into three layers: (1) The *layer of the neuro-epithelium*, composed of two strata, namely, the *layer of rods and cones* and the *external nuclear layer*, the former constituting the specialized outer portions and the latter the nucleated bodies of the *visual cells*; (2) the *layer of the bipolar cells*, which by some authorities are looked upon as the peripheral visual neurons; (3) the layer of the ganglion-cells.

The long processes, or axons, of the ganglion-cells pass into the *nerve-fiber layer of the retina*, reaching the *papilla* or *nerve-head*, and proceed to the *optic nerve*. Having reached the *optic chiasm*, a portion of the fibers of one optic nerve cross over and enter the *optic tract* of the opposite side, forming the *crossed fasciculus*, while a certain number of other fibers do not cross, but enter the optic tract of the same side, forming the *non-crossed fasciculus*. The non-

<sup>1</sup> The terms *hemioopia* and *hemianopsia* are often used synonymously. Really, hemioopia signifies loss in the perceptive power of one-half of the retina, while hemianopsia means obscuration of one-half of the visual field (Seguin). Other names which are used are hemianopia and hemiablepsia.

crossed fasciculus arises chiefly from the temporal side of the retina, while the crossed fasciculus arises from the ganglion-cells of the nasal side of the retina. The bundle from the macula lutea, called the *macular fasciculus*, or *papillomacular bundle*, in general terms, is situated in the central part of the optic nerve and maintains its central position in the optic chiasm and in the optic tract, and is composed of crossing and direct fibers. The optic tract on each side behind the chiasm passes around the cerebral peduncle of the same side and arrives at the junction of the interbrain and midbrain, and divides into a lateral and a medial root. The fibers of the lateral root terminate in the *lateral geniculate body*, in the *pulvinar of the thalamus*, and in the *superior colliculus of the corpora quadrigemina*. These structures have been designated the *primary visual ganglia* or *primary optic centers*.<sup>1</sup> The corpora quadrigemina are not regarded as concerned in the act of vision, but in the activity of the pupil. The medial root of the optic tract has no connection either with the retina or with the optic centers of the interbrain and midbrain.

From the regions just described fibers proceed backward through the posterior part of the *internal capsule* to the cortex under the name of the *optic or visual radiations*, or *fibers of Gratiolet* or of *Wernicke*. Passing through the internal capsule, they cross the sensitive fibers coming down from the hemisphere, and then, spreading out like a fan, rise upward, wind outside of the tip of the lateral ventricle, to reach their destination at the lower part of the median surface of the *occipital lobe*—that is, the cortical termination of the visual tracts. The exact area occupied by the cortical center of vision has not been determined. In general terms it is situated about the *cuneus* and *calcarine fissure*, and does not comprise the whole of the occipital lobe.

By comparing the description of the varieties of hemianopsia which follow with the diagram on the opposite page, the student will understand the mechanism of their development.

The following from Seguin explains the lettering of the illustration :

*L. T. F.*, left temporal half-field ; *R. N. F.*, right nasal half-field ; *O. S.*, left eye ; *O. D.*, right eye ; *N.*, nasal, and *T.*, temporal halves of the retinas ; *N. O. S.*, left optic nerve ; *N. O. D.*, right

<sup>1</sup> According to W. G. Spiller, the chief "primary" optic center is the external geniculate body. The pulvinar of the optic thalamus is also an important "primary" optic center. The anterior colliculus of the quadrigeminal body in man has an unimportant relation to vision. The hypothalamic body, the habenula, the internal geniculate body, probably are not part of the visual system (consult Spiller, "A Case of Complete Absence of the Visual System in an Adult," *Univ. of Penna. Medical Bulletin*, February, 1902).



optic nerve; *F. C. S.*, left crossed fasciculus; *F. L. D.*, right lateral or non-crossed fasciculus; *C.*, Chiasm or decussation of the fasciculi; *T. O. D.*, right optic tract; *T. O. S.*, left optic tract; *C. G. L.*, corpus geniculatum laterale (medial corpus geniculatum and its arms are omitted); *L. O.*, optic lobes (corpora quadrigemina); *P. O. C.*, primary optic centers (including corpora quadrigemina, corpora geniculata, and pulvinar of the optic thalamus); *F. O.*, optic fasciculus, radiating visual fibers of Gratiolet in the internal capsule; *C. P.*, posterior horn of the lateral ventricle; *G. A.*, region of the gyrus angularis; *L. O. S.*, left occipital lobe; *L. O. D.*, right occipital lobe; *Cu.*, cuneus and subjacent gyri constituting the cortical

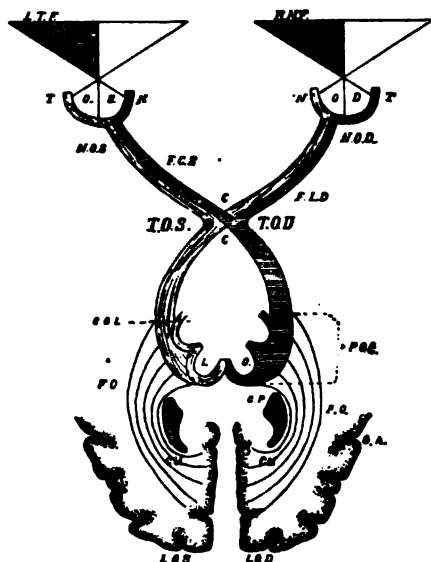


FIG. 166.—Diagram illustrating the visual path and its relation to the visual field, left lateral hemianopsia being shown (Seguin).

visual center in man. The shaded lines represent the parts connected with the right halves of the retinas.

**Varieties of Hemianopsia.**—Hemianopsia is divided into *horizontal*, in which the dividing-line between the darkened and preserved field is horizontal; and *vertical*, in which the dividing-line is vertical.

1. *Horizontal hemianopsia* (altitudinal) may be inferior or superior, both lower or both upper half-fields being wanting. In addition to diseases of the eye, it is possible that such a

condition could arise under the influence of a lesion so situated as to press upon the upper or lower part of the chiasm, or downward upon one optic tract, or upon the lower or upper part of both optic nerves. A double lesion in front of the chiasm may produce loss of the upper half of the field in one eye and of the lower half of the field in the other eye.

2. *Vertical Hemianopsia*.—This is subdivided into several varieties:

(a) *Bitemporal hemianopsia* (peripheral), in which both temporal fields are wanting.

(b) *Binasal hemianopsia*, in which both nasal fields are wanting, is extremely rare; it necessitates a lesion on both

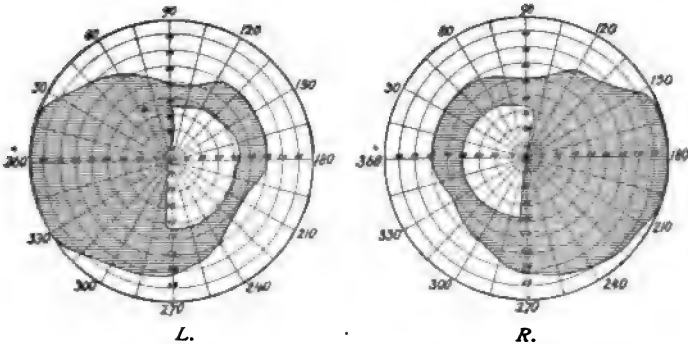


FIG. 167.—Bitemporal hemianopsia. The shaded areas represent the portions of the fields which are dark, and it is evident that there is entire loss of both temporal fields and some contraction of the preserved fields (from a case of acromegaly).

sides of the chiasm, or one on the outer side of each optic nerve, which disables the direct fibers.

(c) *Homonymous hemianopsia* (central), in which the corresponding half of the field in each eye is wanting: thus, both right or both left fields are darkened, in the former case indicating loss of function of the left half of each retina and designated *right homonymous lateral hemianopsia*, and in the latter case indicating loss of function of the right half of each retina, and designated *left homonymous lateral hemianopsia* (Fig. 168).

This is the commonest form of hemianopsia.

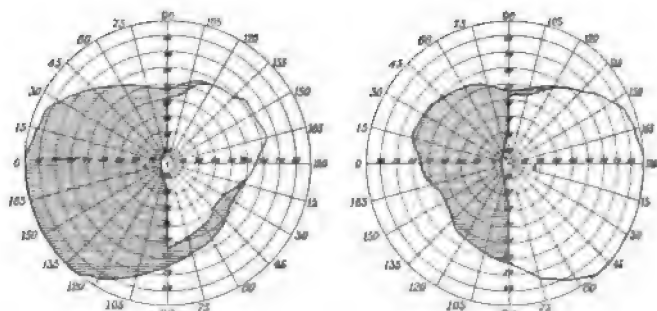


FIG. 168.—Left homonymous hemianopsia, from a case of gunshot wound, with suspected lesion of the right cuneus. The shading shows where vision was lost (from a case under the care of Dr. S. Weir Mitchell in the Infirmary for Nervous Diseases).

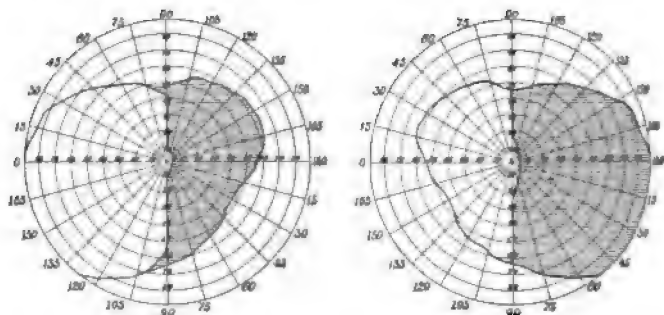


FIG. 169.—Right homonymous hemianopsia (from a case under the care of Dr. Wharton Sinkler).

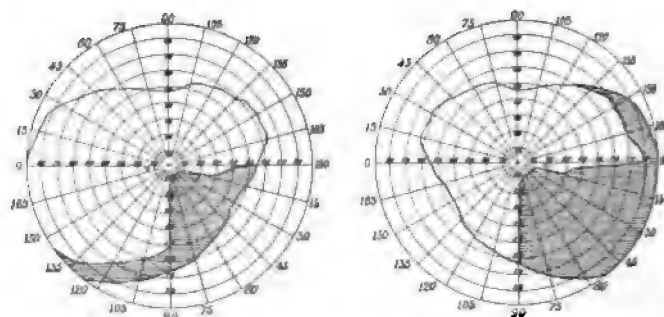


FIG. 170.—Quadrant homonymous anopsia, shading as before. A quadrant of each field is wanting. The lesion is probably in the cuneus.

Hemianopsia may be *complete*—*i. e.*, the entire half of each field is wanting, or *incomplete*—*i. e.*, a portion of each half-field

is wanting, the defect usually being in the form of a quadrant (Fig. 170). The preserved half-fields may be of their normal size, or they may exhibit concentric contraction.

Finally, the hemianopsia may be *absolute*—i. e., all the three functions of sight (perception of light, of form, and of color) are wanting, or it may be *relative*—i. e., perception of color only is lacking, light-sense and form-sense being preserved; or perception of color and form is wanting in the deficient area of the field, but the light-sense is preserved. Those cases in which the half-defect is present for colors alone are described under the name *homonymous hemiachromatopsia*. They probably represent a cortical lesion of less intensity than one which produces absolute hemianopsia. In a remarkable case of this kind which the author has seen with Dr. J. William White, at the onset the hemianopsia was absolute; later light-sense and form-sense returned. The obliteration of the color-sense remains, although in all other respects the patient has recovered. Non-cortical lesions may also produce hemiachromatopsia.

**Peculiarities of the Dividing-line.**—The dividing-line may exactly cut the fixing-point, or, as is usual, it may pass around this point and leave it within the region of preserved vision. The want of uniformity between the seeing and the blind areas may be manifested by the failure of the dividing-line to coincide with the vertical meridian for some distance, by its assuming an oblique or irregular direction, or by forming an open angle. A number of theories have been advanced to account for these peculiarities. They have been explained by Schmidt-Rimpler by assuming that there are anastomoses of the fibers from each optic tract in the retinas as well as in the optic nerves and chiasm.

A number of cases of *double* homonymous hemianopsia are recorded, in which there was preserved a small central field of each eye. This indicates that there is a region in the cortical visual centers which supplies the macula lutea, and that this has not been destroyed. The author has studied one case with Dr. T. D. Dunn.

**Significance of Hemianopsia.**—1. Bitemporal hemianopsia

is caused by a lesion—tumor, aneurysm, or fracture, involving the crossing fibers from both optic tracts in the middle of the chiasm. A unilateral hemianopsia, if not caused by disease within the eye, could originate from injury to one optic nerve.

2. Homonymous lateral hemianopsia is caused by a lesion situated in the occipital lobe, the optic radiations, the internal capsule, the primary optic centers, or the optic tract (Fig. 166).

(a) The lesion in hemianopsia is on the opposite side of the dark fields.

(b) If the preserved fields are accompanied by concentric contraction, the smaller half-field will be in the eye opposite to the lesion; contraction of the preserved half-field is most common with lesions of the cortex, but also may occur in lesions of the tractus.

(c) If the hemianopsia is relative, the lesion is probably in the cortex; but cortical lesions are not excluded by absolute hemianopsia.

(d) A lesion confined to the cuneus, or to it and the gray matter immediately surrounding it, on the mesial surface of the occipital lobe, produces homonymous lateral hemianopsia without motor or sensory symptoms, at least without these as a direct consequence of the lesion, although they may appear as *indirect*, or, as they are sometimes called, *distant symptoms*.

(e) A lesion producing typical hemiplegia, aphasia, if the right side is paralyzed, little or no anesthesia and lateral hemianopsia, is probably due to disease in the area supplied by the middle cerebral artery.

(f) A lesion causing hemiplegia, hemianesthesia, and lateral hemianopsia is probably situated in the posterior portion of the internal capsule.

(g) A lesion causing hemianesthesia, ataxic movements of one half of the body, no distinct hemiplegia, and lateral hemianopsia could be situated in the posterior lateral part of the optic thalamus.

(h) A lesion causing the symptoms of disease of the base of the brain, associated at the same time with changes in the pupil, changes in the nerve-head, and lateral hemianopsia, could be situated in one optic tract or in the primary optic centers on one side.<sup>1</sup>

(i) Incomplete hemianopsia, assuming usually a quadrant-shaped defect, may be present on account of a lesion confined to the lower half of the cuneus. It may also occur with less definite limitations in lesions of the subcortical substance of the occipital lobe and then may be associated with other symptoms, as hemiplegia and hemian-

<sup>1</sup> The preceding paragraphs have for the most part been condensed from the rules given by Dr. Seguin for the diagnosis of the seat of lesion in cases of hemianopsia.

esthesia. Finally, it may occur from a lesion of the tract, but then will be accompanied by other symptoms indicating basal disease or from a lesion of the external geniculate body.

(j) A hemianopsia in which there is preservation of the light-sense, but loss of either the color-sense or the form-sense indicates that the lesion is in the cortex of the visual center.

**The Pupil in Hemianopsia.**—One of the most important localizing symptoms is obtained by carefully observing the reaction of the pupil in cases of hemianopsia.

The examination should be made as follows: The patient being seated in a dark room with the source of light somewhat behind him, the eye under examination is illuminated by weak light reflected from a plane mirror—as, for instance, the one used in the shadow-test. With the other hand the observer reflects a more intense beam of light by means of the concave mirror of the ophthalmoscope in various directions into the pupillary space, care being taken that the light falls obliquely and is not diffused over the entire retina.

If, in hemianopsia, the light thus thrown upon either the blind or the seeing side of the retina causes contraction of the pupil, the lesion is back of the primary optic centers.

If there is no contraction of the pupil when the ray of light falls upon the blind side of the retina, but there is contraction when it falls upon the seeing side, the lesion is in front of the primary optic centers.

In the former instance the lesion is so situated that there is no disturbance of the sensorimotor arc of the pupils; in the latter the lesion interferes with this arc, and the pupillary change receives the name *hemiopic* or *hemianopic pupillary inaction*. It is often called *Wernicke's symptom*.<sup>1</sup>

<sup>1</sup> Henschen (*Klin. med. anat. Beiträge zur Pathologie des Gehirns*, Th. iii.) concludes that the hemiopic pupillary inaction (abbreviated H. R.) is present in tract lesions, even when minute or merely caused by pressure; lesions of the posterior segment of the thalamus and pulvinar—perhaps from pressure on the tract, or by destroying the brachium arterius; lesions of the chiasm (occasionally absent from unknown reasons); and in lesions of the nerve, with unilateral hemianopsia. It is a difficult symptom to demonstrate (Henschen uses a special lamp). The iris reaction may not be entirely absent when the ray falls on the blind side of the retina, but it is much less marked than the one which follows light stimulus of the opposite side.

## CHAPTER XIX.

### MOVEMENTS OF THE EYEBALLS AND THEIR ANOMALIES.

**Anatomy and Physiologic Action of the Ocular Muscles.**—The movements of the eye are controlled by the action of six muscles, four straight and two oblique, in general terms situated in the orbital region.

1. The *external rectus* arises by two heads, respectively from the outer margin of the optic foramen and the common tendon of the inferior and internal recti, and in part from a process of bone on the lower margin of the sphenoid fissure. Its tendon is inserted into the sclera 7 mm. from the margin of the cornea. It is supplied by the *sixth* or *abducens nerve*. Its preeminent<sup>1</sup> muscular action is *abduction*—that is, it rotates the eye directly outward.

2. The *internal rectus* arises from the optic foramen by a tendon common to it and the inferior rectus, and passes forward to be inserted by a tendinous expansion into the sclerotic coat 5 mm. from the margin of the cornea. It is supplied by one of the three branches of the inferior division of the *third* or *oculomotor nerve*. Its preeminent muscular action is *adduction*—that is, it rotates the eye directly inward.

3. The *superior rectus* arises from the upper margin of the optic foramen and from the fibrous sheath of the optic nerve, and is inserted by a tendinous expansion into the sclerotic coat 8 mm. from the margin of the cornea. It is supplied by the superior division of the *third* or *oculomotor nerve*. Its preeminent muscular action is *elevation* or *superduction*—that is, it rotates the eye upward. It also adducts it and rotates the upper end of the vertical meridian of the cornea inward (*inward torsion* or *intorsion*).

4. The *inferior rectus* arises from the optic foramen by a

<sup>1</sup> This term is borrowed from Maddox.

## Anatomy and Physiologic Action of Muscles 563

tendon common to it and the internal rectus and passes forward to be inserted by a tendinous expansion into the sclerotic coat, 6 mm. from the margin of the cornea. It is supplied by one of the three branches of the inferior division of the *third* or *oculomotor nerve*. Its preeminent muscular action is *depression*, or *subduction*—that is, it rotates the eye downward. It also adducts it and rotates the vertical meridian of the cornea outward (*outward torsion*, *extorsion*).

5. The *superior oblique* (trochlear) is situated at the upper and inner side of the orbit, and arises above the inner margin of the optic foramen. It proceeds to the inner angle of the orbit, at which point its rounded tendon passes through a fibrocartilaginous pulley occupying a fossa just within the supra-orbital margin of the frontal bone, and is then reflected backward, outward, and downward, to be inserted about 18 mm. from the edge of the cornea between the superior and external recti. It is supplied by the *fourth* or *trochlear nerve*. Its preeminent muscular action is *intorsion*—that is, it rotates the vertical meridian inward. It also depresses the eye and abducts it.

6. The *inferior oblique* is situated at the bottom of the orbit and arises from a depression in the orbital plate of the superior maxillary bone. Passing beneath the inferior rectus, it is directed outward, backward, and upward, and reaches its insertion into the sclera by means of a thin tendon about 19 mm. from the corneal margin, within the position of the external rectus. It is supplied by the largest branch of the superior division of the *third* or *oculomotor nerve*. Its preeminent muscular action is *extorsion*—that is, it rotates the vertical meridian outward. It also elevates the eye and abducts it.

The starting-point from which the actions of the muscles are reckoned is the *primary position* of the globe, defined by Mauthner as that position of the eyes from which the visual lines can be moved without the eyes being revolved around their axes. The eyes occupy about this position when they are directed straight forward, the head being held erect, and a distant object, situated in the median line of the visual plane, is observed with practically parallel visual lines. Posi-



## 564 Movements of the Eyeballs and their Anomalies

tions of the eyes other than this are called *secondary positions*.

### **Rotation of the Eyeball around the Visual Line.—**

The movements of the eyeball directly upward (combined action of superior rectus and inferior oblique), or downward (inferior rectus and superior oblique), or inward (internal rectus alone), or outward (external rectus alone), are around axes which are perpendicular to the visual line; consequently, if a vertical plane is passed through the visual line, its direction will not be deviated from the perpendicular in movements of the eyeball directly upward, downward, inward, or outward.

In *oblique* movements of the eyeball, upward and inward (superior and internal rectus, with inferior oblique); downward and inward (inferior and internal rectus, with superior oblique); upward and outward (superior and external rectus with inferior oblique); or downward and outward (inferior and external rectus with superior oblique), the eyeball is rotated around an axis which is situated obliquely to the visual line; the vertical plane of the eye is deviated in consequence to the right or left of the perpendicular.

The *vertical plane* is denoted by the term *vertical meridian*, and may be described as a line passing through the center of either pupil perpendicular to the line joining the centers of the two pupils in the primary position of the eyeballs; this line joins two opposite points of the corneal margin.

In any extreme movement in a diagonal direction this line will be observed to rotate like the spokes of a wheel (*wheel-movement* or *torsion*). The eyeball appears to rotate around the visual line; this is effected by the superior and inferior recti and the superior and inferior oblique muscles. The upper extremity of the vertical meridian of the cornea is deviated outward (toward the temple) by the inferior recti and inferior oblique muscles; and inward (toward the nose) by the superior recti and superior oblique muscles. The deviation of the vertical meridian is greatest when the axis of rotation coincides with the visual line.

The superior and inferior recti exercise the greatest degree

## Rotation of the Eyeball around the Visual Line 565

of torsion when the eyeball is drawn toward the nose, and either upward or downward.

The oblique muscles, on the contrary, exercise their maximum amount of torsion when the eyeball is drawn toward the temple, and either upward or downward. The inferior oblique, while it aids the superior rectus in upward movements, antagonizes it in the rotation of the vertical meridian and the movement of the eyeball inward.

The visual line coincides most nearly with the axis of rotation of the superior and inferior recti, when the eyeball is drawn toward the nose; and most nearly with that of the superior and inferior oblique muscles, when the eyeball is

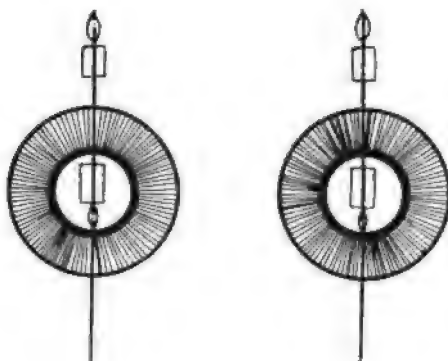


FIG. 171.—Normal position of eyes (Wallace).

turned toward the temple. The superior oblique aids the inferior rectus in drawing the eye downward, but antagonizes it in the rotation of the vertical meridian and in the movement of the eyeball inward.

When the muscles are evenly balanced, the eyes in the extreme diagonal movements undergo a symmetric deviation of the vertical meridians. The effect of this on the projection of the retinal images is not disturbing, the obliquity being corrected by the judgment or by a countermovement of the head (Fig. 171).

In cases of paralysis of one or more of the eye muscles, this harmony no longer exists, and the resulting diplopia

## 566 Movements of the Eyeballs and their Anomalies

from unequal movements of the eyes is associated with obliquity of the double images toward each other.

This obliquity can be simplified for study by dividing it into two kinds: either the vertical meridians incline toward each other by their upper extremities; or else they diverge from each other.

The meridians *diverge* from each other when the upper extremity of one vertical meridian is directed toward the temple, while the vertical meridian of the other eye remains perpendicular. An object extending in a vertical direction—for example, a candle—would form an inverted image on the retina of the eye whose vertical meridian is tilted toward the temple by its upper extremity, in which the flame of the candle would occupy the lowest portion of the image lying somewhat on the temporal half of the retina, while the lower portion of the candle would occupy the highest portion of the image, somewhere on the nasal half of the retina (Fig. 172). In accordance with the law of projection, images on the nasal half of the retina are referred to the temporal portion of the field, and images on the temporal half of the retina are referred to the nasal portion of the field. With the vertical meridian tilted toward the temple the candle forms an image on the retina which is projected outward, so that it seems to converge by its upper extremity toward that of the other eye when the diplopia is homonymous; when crossed diplopia exists, it seems to diverge.

The meridians *converge* toward each other when the upper extremity of one vertical meridian is tilted toward the nose, while the vertical meridian of the other eye remains perpendicular.

When the vertical meridian is tilted toward the nose by its upper extremity, the image of the candle occupies, with its lower portion, a point in the nasal half of the retina, and with its upper portion a point in the temporal half of the retina. It is projected outward in such a manner that it seems to lean away from the image of the other eye when the diplopia is homonymous; when crossed diplopia exists, it seems to lean toward the image of the other eye (Figs. 172 and 173). The eye in

which the vertical meridian tilts, or the eye in which the vertical meridian does not tilt, may be the defective one. The

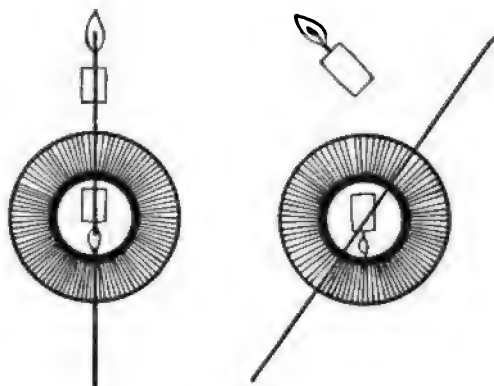


FIG. 172.—Vertical meridian of left eye diverging by its upper extremity (Wallace).

image of the paralytic eye is always the one which appears to be oblique (see pp. 576–582).

**Associated Movements.**—Except under pathologic circumstances, there is coordination in the movements of the eyes, and the movement of one eyeball is associated with that

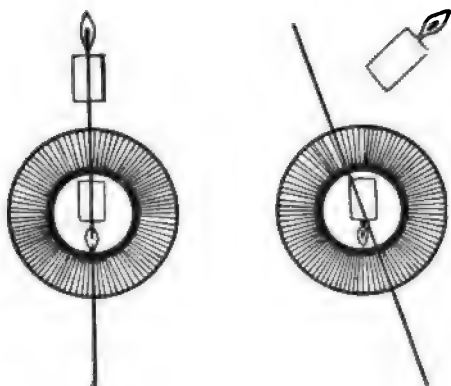


FIG. 173.—Vertical meridian of left eye converging by its upper extremity (Wallace).

of its fellow. In other words, both eyes are used for seeing (*binocular vision*), and are so adjusted that the image of the object regarded falls simultaneously on both maculas (*binocular*

## 568. Movements of the Eyeballs and their Anomalies

*fixation*). If a distant object is to be looked at and the right eye is turned to the right, the left eye is also turned to the right and to the same extent as its fellow, because of the associated action of the external rectus of the right eye and the internal rectus of the left eye under the same innervation-impulse. If one eye is elevated, the other is also elevated; if one is depressed, the other is also depressed. These are associated movements in the same direction.

If a near object is to be looked at, the visual axes converge for the point at which it is situated, because of the associated action of the internal recti of the two eyes (*convergence* or *accommodative* movement); if the eyes are removed from this point and directed to a distant object, the visual axes tend to parallelism, because of the action of both external recti.

If the associated movements of the eyes were not thus regulated by equal impulses from the coordinating center, single vision would not be possible, because the images of any object would not fall upon *corresponding points* of the two retinas. Inasmuch as every normal individual has two normally constructed eyes, he must receive from every object two sets of sensations, which are blended into one when the movements of the eyes are so arranged that the images fall upon corresponding retinal areas.

A point situated anywhere upon the right side of one retina has its corresponding point upon the right side of the other retina, and points on the left side of one correspond with points on the left side of the other. The upper half of the retina of the right eye corresponds to the upper half of the retina of the left eye, and the lower half of the right to the lower half of the left; the nasal side of the right eye corresponds with the malar side of the left, and the malar of the right with the nasal of the left. If, for any reason, the movements of the eyes become disarranged so that the images do not fall upon corresponding or identical retinal areas, the images become double.

The desire for *binocular single vision*, or single vision with the two eyes, which depends upon the blending of the two sets of sensations, or, as it is also called, *fusion*, is believed to

be the origin of the impulse which directs the movements of the eyeballs, especially in association in the same direction.

In addition to this desire for blending the two sets of sensations into one, seen in the associated movements of the eyes in the same direction, there is also another regulating factor—*i. e.*, the connection between convergence and accommodation (see page 50).

**Overcoming Prisms.**—The power which the eyes have of producing fusion of the retinal images is represented by the value, in degrees, of the prism which they can overcome. As has been explained on page 80, this value for the external recti is equal to about  $8^{\circ}$ ; for the internal recti, from  $30^{\circ}$  to  $60^{\circ}$ ; and for the vertical muscles, about  $3^{\circ}$  to  $4^{\circ}$ . When a prism is placed before one eye with its base inward and diplopia is produced, an outward rotation of the eye occurs, and when the prism is placed with its base outward, an inward rotation of the eye takes place, and the influence of the prism is overcome, so that single vision again is possible within the limitations just stated.

**Field of Fixation.**—This includes all points which the eye under observation can successively fix, the head being perfectly stationary. The field of fixation of an amblyopic eye may be determined by watching the image of a candle-flame on the center of the cornea as the eye follows the test-light moved along the perimeter arc until the limit of movement is reached. Ordinarily the patient should be seated in the position for testing the visual field before the perimeter, with the semicircle horizontal, and the eye (the head being rigid) made to follow a word composed of small test-letters, and the point where vision ceases to be distinct marked on successive meridians. In place of letters, two fine dots set close together on a card may be employed, and the point noted where the dots cease to appear as two.

Landolt's measurements of the field of fixation under normal conditions are as follows: Outward, 45–50; inward, 45; upward, 35–40; downward, 60. Duane's average measurements are: Outward, 51; inward, 53; upward, 43; downward, 63.

## 570 Movements of the Eyeballs and their Anomalies

G. T. Stevens determines the rotations of the eyes with a special instrument called a *tropometer*. According to him, the most favorable rotations are: Outward, 50; inward, 55; upward, 33; downward, 50.

**Strabismus, Squint, or Heterotropia.**—Under the gen-

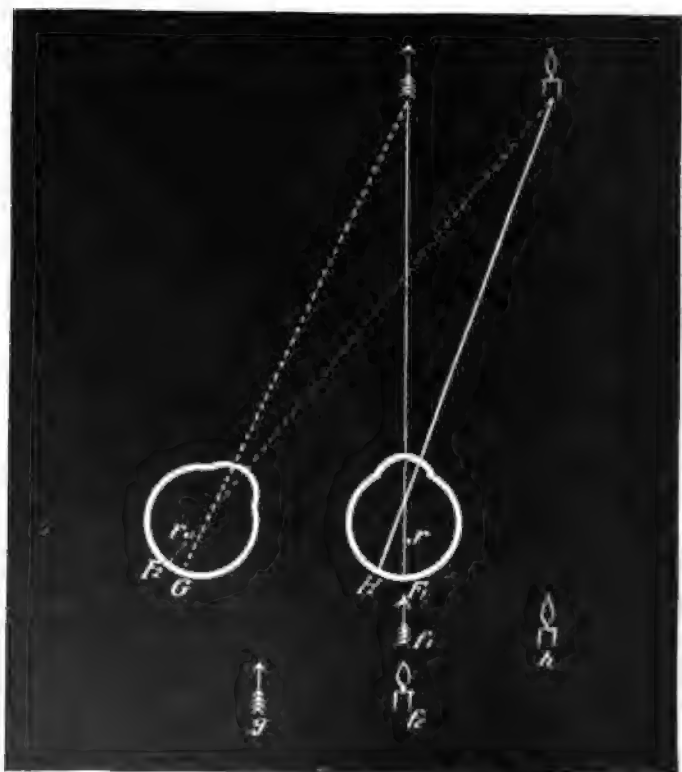


FIG. 174.—Convergent strabismus. Position and projection of the images. An object situated at the intersection of the visual lines would produce single vision (James Wallace).

eral term *strabismus* or *squint* are included those conditions which occur when the visual axis of one eye is deviated from the point of fixation. The eye the visual axis of which is directed to the object fixed is termed the *fixing eye*; the other eye is termed the *squinting* or *deviating* eye. The deviation may be inward (*strabismus convergens*), outward (*strabis-*

*mus divergens*), upward (*strabismus sursum vergens*), or downward (*strabismus deorsum vergens*).

1. **Convergent Strabismus, or Esotropia.**—In this form of squint the visual line of one eye is directed to the object fixed. The visual line of the other eye is deviated inward, and intersects that of the sound eye at some point nearer than the object fixed. The image of an object situated on the visual line of this eye would be formed on the fovea, and projected to the same point in the field of fixation.

Figure 174 represents a convergent squint of the left eye, and serves to explain the results of an inward deviation of one eye from any cause.

The center of rotation is seen at  $r$ . The arrow is the object fixed; its image is formed on the fovea of the right eye  $F_1$ , and its position in the field is denoted by  $f_1$ . The candle forms its image on the retina of the right eye to the left of the fovea at  $H$ ; its image is properly projected to the right, and its position in the field is denoted by  $h$ . The visual axis of the left eye is directed to the candle; its image is formed on the fovea at  $F_2$ , and its position in the field is denoted by  $f_2$ , identical with that of  $f_1$ , because formed on an identical point of the retina. The arrow forms an image on the retina of the left eye at  $G$ , to the right of the fovea; it is consequently projected to the left of that of  $F_2$ , and its position in the field is denoted by  $g$ .

The right eye projects the images correctly; the left eye makes a false projection of the images to the left side—*i. e.*, to the side of the squinting eye. The diplopia is *simple* or *homonymous*.

2. **Divergent Strabismus, or Exotropia.**—In this form of squint the visual line of one eye fixes the object, while the visual line of the other eye lacks the necessary movement inward to intersect that of its fellow at the point of fixation.

As long as the visual axis of the affected eye intersects that of the sound eye in its anterior extremity, the affection may be denominated *insufficiency of convergence*. When the visual axes no longer intersect anteriorly, but diverge from each other so that their posterior extremities intersect, the affection may be denominated *divergent squint*.

Fig. 175 represents a divergent squint of the left eye, and explains the effects of an outward deviation of one eye from



## 572 Movements of the Eyeballs and their Anomalies

any cause, upon the position of the images of an object which is fixed.

The center of rotation is at  $r$ . The arrow is the object fixed; its image is formed on the fovea of the right eye at  $F_2$ , and its position in the field is denoted by  $f_1$ . The candle forms its image on the retina of the right eye to the right of the fovea at  $H$ ; its image is prop-

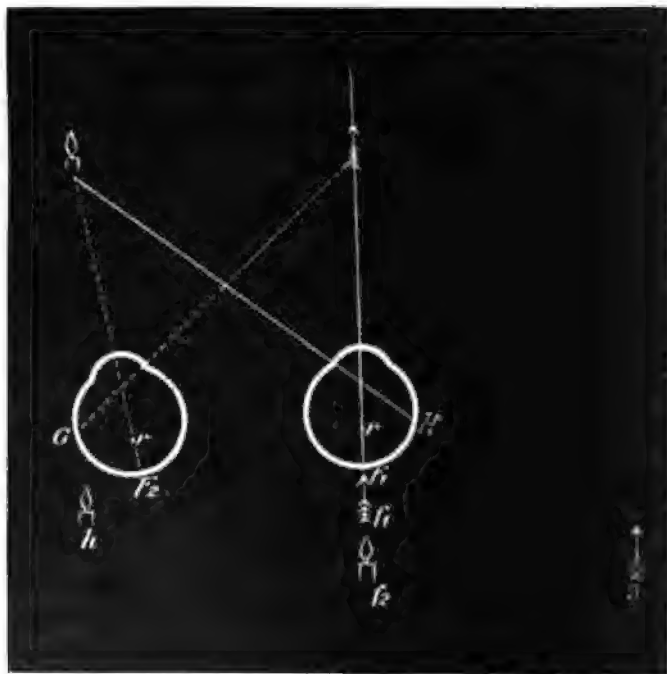


FIG. 175.—Divergent strabismus. Position and projection of the images. An object at the intersection of the lines  $H$  and  $G$  would produce single vision (James Wallace).

erly projected to the left and its position in the field is denoted by  $h$ . The visual axis of the left eye is directed to the candle; its image is formed on the fovea at  $F_2$ , and its position in the field denoted by  $f_2$ , identical with that of  $f_1$  because formed on identical points of the retina. The arrow forms an image on the retina of the left eye at  $G$ , to the left of the fovea; it is consequently projected to the right of that of  $F_2$ , and its position in the field is denoted by  $g$ .

The right eye projects the images properly; the left eye makes a false projection toward the right side—*i. e.*, the side

opposite to the squinting eye. The diplopia is *crossed* or *heteronymous*.

**3. Upward and Downward Squint, or Hypertropia.**—If vertical deviation (upward or downward) causes diplopia, it is crossed, the upper image corresponding with the lower eye. Simple vertical deviation without lateral is rare. Generally



FIG. 176.—Convergent strabismus with decided upward deviation (from a patient in the Philadelphia Hospital).

in lateral strabismus the squinting eye deviates upward, but may also turn downward (Schweigger). According to Hantsell, functional internal squint (*esotropia*) is always associated with upward deviation (*hypertropia*).

**Paralysis of the External Ocular Muscles** (*Paralytic Strabismus*).—This may be *complete* (the muscle is entirely paralyzed) or *incomplete* (the muscle is partially paralyzed).

## 574 Movements of the Eyeballs and their Anomalies

**A. General Symptoms.**—Certain symptoms are common to paralysis of the external eye muscles.

1. *Loss of Binocular Single Vision, or Diplopia.*—The cause of this, evident from the previous explanations, depends upon the deviation of the affected eye so that the images from an object are no longer fused, owing to their failure to fall upon "identical points" in the two retinas. Diplopia increases as the object is moved to the side of the paralyzed muscle. In slight cases it amounts only to indistinct vision.

2. *Non-Correspondence of the Direction of the Two Eyes, or Strabismus.*—This depends upon the deviation to which the affected eye is subjected by the tone of the unresisted action of the muscle which is the antagonist of the paralyzed muscle, and also, in part, in old cases, upon the effect of secondary contractures. Squint is not always plainly manifest and may appear only if an attempt is made to move the eye in the direction of the action of the palsied muscle.

3. *Loss or Limitation of Movement ("Primary Deviation").*—The limitation of movement is always in the direction of the action of the affected muscle; consequently the deviation of the eye is in a direction opposite to the action of the muscle.

4. *Deviation of the Sound Eye, while the Affected Eye Fixes ("Secondary Deviation").*—During the act of fixation by the affected eye the same degree of nervous impulse passes from the center to the muscles of the affected eye and to those of its non-affected associate; the former requires an abnormally great impulse to stimulate its movement, and hence the latter is overexcited, and the resulting movement is excessive. The secondary deviation, therefore, is greater than the primary deviation.

In order to demonstrate this the sound eye is covered with the hand, while the affected eye is directed toward an object held at a distance of about one foot. The covering hand is then moved from the sound to the affected eye. In order to fix the object, the sound eye must now move in a direction opposite to that toward which the paralyzed muscle rotates the ball. This backward movement represents the degree of previous excess called into existence by the undue amount of

nerve-force which the normal muscle originally received. Thus primary and secondary deviations are in opposite directions, but both in the line of action of the affected muscle.

5. *False Projection of the Field of Vision.*—This depends upon an inaccurate estimation of the position of an object situated in such a portion of the visual field that it requires an effort on the part of the affected muscle to turn the eye toward it. A normal individual (his head being stationary, and one eye being closed, *e. g.*, the right) can readily and accurately touch an object lying within his reach to the left of the median line, because the degree of innervation required to make the lateral movement of the eye in order to see the object gives the necessary information, based on experience, how far to the left the object lies. Under the same circumstances an individual with a paretic left external rectus, instead of touching the object, would pass his hand beyond it—*i. e.*, to the left of it, because the excessive innervation which is now necessary to make the lateral turn gives the impression that the object lies farther to the left. In other words, the object is projected to a position in the visual field which it does not have.

6. *Vertigo.*—This depends, both eyes being open, upon the diplopia and the confusion arising from trying to distinguish between the real and the false image. If one eye (the unaffected eye) is closed, it depends upon the condition described in the preceding paragraph.

In a paretic condition of the muscles which rotate the eye downward vertigo may result from an erroneous localization of objects in the lower field, as they seem to lie in a plane deeper than they really are. For these reasons patients with ocular palsies commonly close the affected eye, although closure of either eye would remove the diplopia.

7. *Altered Position of the Carriage of the Head.*—This depends upon the impulse of the patient to carry his head in that direction in which he is least troubled by the double images, and this is usually in the direction toward which the affected muscle moves the eye.

**B. Varieties of Diplopia.**—There are two varieties of diplopia, according to the relation which the double images

## 576 Movements of the Eyeballs and their Anomalies

bear to the eyes. If the right image pertains to the right eye, and the left image to the left eye, the diplopia is designated "*simple*" or "*homonymous*"; if the right image pertains to the left eye, and the left image to the right eye, the diplopia is named "*crossed*" or "*heteronymous*." The explanation of these conditions has been given (consult Figs. 174 and 175).

If the two images are on a horizontal line, the phenomenon is called *horizontal diplopia*. Vertical displacement of the double images constitutes *vertical diplopia*.

**C. Special Symptoms.**—The following paragraphs contain the most important symptoms peculiar to paralysis of individual muscles. For convenience it is supposed that the *right* eye is affected.

**1. External Rectus.**—The following phenomena may be present:

(a) *Horizontal homonymous diplopia*, the images being side by side and parallel, if the eyes are directed on a horizontal level, the distance between them widening as the test-object is moved to the right—that is, the maximum diplopia is to the right.

If the test-object is moved to the right and above, and the eyes are directed toward it, the false image (image of the right or affected eye) diverges from the real image (image of the left or unaffected eye). This occurs because, under these circumstances, the movement of the right eyeball toward the temple is limited by the feeble external rectus, and the eyeball fails to come into the position where the inferior oblique has its favorable condition for rotating the vertical meridian outward; hence the vertical meridian remains near to a perpendicular, while that of the sound eye is tilted toward it. There is divergence of the vertical meridians (the false image converges toward the real one) when the eyes are directed downward and toward the right, because the eyeball fails to come into a favorable position to have its vertical meridian tilted toward the nose by the superior oblique, while that of the other eye is tilted toward the temple by the inferior rectus.

(b) *Convergent strabismus*, which increases as the eye

attempts to follow an object which is moved toward the right, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is inward; the *false projection of the field of vision* is to the right side, and



FIG. 177.—*A*, Position of images in paralysis of left external rectus, and *B*, in paralysis of right externus. The false image is drawn in outline (after Fuchs).

the *face is turned to the right—i. e.*, to the side of the affected muscle.

## 2. Internal Rectus.—There are present :

(a) *Horizontal crossed diplopia*, the images being side by side and parallel, if the eyes are directed along a horizontal level, the distance between them widening as the test-object is moved to the left, or if the eyes are directed upward—that is, the maximum diplopia is to the left (Fig. 178).

If the test-object is moved to the left and above, and the



FIG. 178.—*A*, Position of images in paralysis of left internal rectus, and *B*, in paralysis of right internus. The false image is drawn in outline (after Fuchs).

eyes are directed toward it, the image of the affected eye is lower than that of the unaffected eye, and its upper extremity inclines toward it; if the test-object is moved to the left and downward, the false image is higher and its lower extremity inclines away from that of the real image. These inclinations occur because, under these circumstances, the left eyeball is placed in a favorable position for one of the oblique muscles

## 578 Movements of the Eyeballs and their Anomalies

to rotate it, while the right eye is not brought in sufficiently for the superior or inferior rectus to exercise its torsion effect; consequently, the vertical meridians diverge on looking upward and converge on looking downward toward the left side.

(b) *Divergent strabismus*, which increases when the eye attempts to follow an object moved to the left, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is outward, the *false projection of the visual field* is to the left side, and the *face is turned to the left*—i. e., to the side of the affected muscle.

### 3. Superior Rectus.—There are present :

(a) *Vertical crossed diplopia* in the upper field, the images



FIG. 179.—A, Position of images in paralysis of left superior rectus, and B, in paralysis of right superior rectus (Fuchs).

being one above the other, the image of the affected eye being higher than its fellow and inclined to the left (healthy side), and the vertical distance between them (difference in height) widening as the test-object is moved upward and to the right—that is, there is maximum diplopia in looking up and to the right (Fig. 179).

If the test-object is moved upward and to the left, and the eyes are directed toward it, the obliquity of the images increases—i. e., the false image is still more inclined toward the sound side, away from that of the other. This occurs because, under these circumstances, the inferior oblique rotates the vertical meridian of the sound eye to the left, while the affected eye, owing to the loss of power in the superior rectus,

is unable to deviate its vertical meridian from the perpendicular; therefore the two meridians diverge, but the diplopia being crossed, the images also diverge.

(b) *Downward strabismus*, which increases when the eye attempts to follow an object moved upward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is upward, the *false projection of the visual field* is too high, and the *face is directed upward and to the right*.

#### 4. Inferior Oblique.—There are present :

(a) *Vertical homonymous diplopia (sometimes crossed)* in the upper field, the images being one above the other, the image of the affected eye being higher than its fellow and inclined to the right,—i. e., to the affected side,—the vertical distance be-



FIG. 180.—A, Position of images in paralysis of left inferior oblique, and B, in paralysis of right inferior oblique (after Fuchs).

tween them (difference in height) widening as the test-object is moved upward and to the left—that is, there is maximum diplopia on looking up and to the left.

If the test-object is moved upward and to the right and the eyes are directed toward it, the obliquity of the images increases—i. e., the false image is still more inclined away from the sound side. This occurs because, under these circumstances, the vertical meridian of the right eye is not tilted toward the temple, owing to loss of power in the inferior oblique, while that of the left eye is tilted toward the nose by the superior rectus, now in its best position for tilting the vertical meridian inward; therefore the two meridians incline toward each other by their upper extremities.



## 580 Movements of the Eyeballs and their Anomalies

(b) The *direction of the affected eye* is downward and inward, which is more noticeable when the eye attempts to follow an object moved upward and outward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is upward and inward, the *false projection of the visual field* is too far upward, and the *face is directed upward and toward the left*.

### 5. Inferior Rectus.—There are present :

(a) *Vertical crossed diplopia* in the lower field, the images being one above the other, the image of the affected eye being lower than its fellow and inclined to the right,—*i. e.*, to the affected side,—and the vertical distance between them (difference in height) widening as the test-object is moved downward



FIG. 181.—*A*, Position of images in paralysis of left inferior rectus, and *B*, in paralysis of right inferior rectus (after Fuchs).

and to the right—that is, there is maximum diplopia on looking down and to the right.

If the test-object is moved downward and to the left, and the eyes are directed toward it, the obliquity of the images increases—*i. e.*, the false image inclines still more toward the affected side. This occurs because, under these circumstances, the superior oblique of the left eye is in its best position for rotating the vertical meridian toward the nose; but the right eye, by reason of its paralyzed inferior rectus, is unable to tilt its vertical meridian to correspond; therefore, the vertical meridian of the right eye remains perpendicular, while that of the left eye inclines toward it. The image of the right eye seems to be the oblique one; the images diverge, but the diplopia being crossed, they seem to converge.

(b) *Upward strabismus*, which increases when the eye at-

tempts to follow an object moved downward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is downward and outward, the *false projection of the visual field* is too far downward, and the *face is directed downward* and to the *right*.

#### 6. Superior Oblique.—There are present :

(a) *Vertical homonymous diplopia (sometimes crossed)* in the lower field, the images being one above the other, the image of the affected eye being lower than its fellow, and inclined to the left,—*i. e.*, to the sound side,—the vertical distance between them (difference in height) widening as the test-object is moved downward and to the left—that is, there is maximum diplopia downward and to the left.



FIG. 182.—*A*, Position of images in paralysis of left superior oblique, and *B*, in paralysis of right superior oblique (after Fuchs).

If the test-object is moved downward and to the right, and the eyes are directed toward it, the obliquity of the images increases—*i. e.*, the false image inclines still more toward the sound side. This occurs because, under these circumstances, the vertical meridian of the left eye is inclined toward the left by the inferior rectus, while that of the right eye is not rotated, owing to the feeble superior oblique; consequently, the meridians diverge.<sup>1</sup>

<sup>1</sup> In paralysis of the inferior rectus the diplopia is usually crossed; this feature helps to distinguish it from paralysis of the superior oblique. In both, the image of the affected eye sometimes seems to stand nearer to the patient than the other image. It should be remembered, however, as Maddox insists, that in paralysis of any one of the obliques a preexisting exophoria may complicate the case to such an extent as to change "homonymous" into "crossed" diplopia, while in paralysis of the superior and inferior recti preexisting esophoria may convert "crossed" into "homonymous" diplopia.

## 582 Movements of the Eyeballs and their Anomalies

(b) The *direction of the affected eye is upward and inward*, and is more noticeable when the eye attempts to follow an object moved downward and outward, during which it will be noticed that there is *limitation of movement* in this direction.

(c) The *secondary deviation* of the sound eye is downward and inward, the *false projection of the visual field* is too far downward, and the *face is inclined downward* and to the *left*.

### 7. Oculomotor Paralysis.—There are present :

(a) *Complete crossed diplopia*, the image of the affected eye being higher than its fellow, and its upper extremity inclined to the right,—*i. e.*, to the affected side,—the distance between them—*i. e.*, the lateral distance—widening as the test-object is moved to the left. If the test-object is moved upward, the difference in height and the inclination of the false image increase.

(b) *Divergent strabismus* and *limitation of movement* in all directions, except outward and slightly downward.



FIG. 183.—Double oculomotor palsy (from a patient in the Philadelphia Hospital).

(c) The *secondary deviation* of the sound eye is outward, the *false projection of the field of vision* is to the inner side, and the *face is inclined toward the right*, the chin being tipped *upward*. In addition, there are ptosis, medium dilatation of the pupil which fails to contract to light, and paralysis of accommodation.

**Method of Examination and Diagnosis of the Affected Eye.**—If the paralysis is complete, there is little difficulty

in making a diagnosis by attention to the prominent symptoms which have been detailed. When the condition is one of partial paralysis (paresis), the diagnosis must be based upon an investigation of the double images.

The patient is seated with the head and eyes in the primary position, four meters from the test-object (a candle-flame), and a trial-frame one side of which carries a red glass is placed in position. Hence if diplopia is developed, one image will be yellow and the other red. The lighted candle is then moved from the median line to the right, to the left, upward and down, while the patient follows these movements with his eyes, the head being stationary. By these manœuvres the following facts will be ascertained :

(1) Double images are chiefly seen when the eyes are turned in a direction requiring an action of the affected muscle. (2) The image of the affected eye (false image) is projected in a direction toward which the paralyzed muscle normally rotates the eye. (3) That image is false (image of the affected eye) which travels farther away from the true image (image of the sound eye) when the test-object is moved in the direction of the paralyzed muscle—*i. e.*, the relative distance of the double images increases under these circumstances.

The effect upon the obliquity of the images and their relation to each other of moving the test-object in oblique directions above and below the horizontal plane must next be studied ; also whether the images are present in all portions of the field of fixation, or confined to a certain area of it.

Many tables have been prepared to aid in the diagnosis of the affected muscle. The following is one, slightly modified, from the arrangement published by Dr. F. C. Hotz :<sup>1</sup>

1. Paralysis of an *internal* or an *external rectus* produces *horizontal diplopia*.

(a) If the diplopia is *homonymous*, paralysis of an *external rectus* is indicated: the external rectus of the right eye if the images separate to the right, and the external rectus of the left eye if they separate to the left.

<sup>1</sup> *International Clinics*, vol. iii., fourth series.

## 584 Movements of the Eyeballs and their Anomalies

(b) If the diplopia is *crossed*, paralysis of an *internal rectus* is indicated: the internal rectus of the left eye if the images separate to the right, and the internal rectus of the right eye if they separate to the left.

2. Paralysis of a *superior rectus* or an *inferior oblique* produces *vertical diplopia* in the upper field.

(a) If the diplopia is *homonymous*, paralysis of an *inferior oblique* is indicated: the right inferior oblique if the image of the right eye is higher, the left inferior oblique if the image of the right eye is lower.

(b) If the diplopia is *crossed*, paralysis of a *superior rectus* is indicated: the right superior rectus if the image of the right eye is higher, the left superior rectus if the image of the right eye is lower.

3. Paralysis of an *inferior rectus* or *superior oblique* produces *vertical diplopia* in the lower field.

(a) If the diplopia is *homonymous*, paralysis of a *superior oblique* is indicated: the right superior oblique if the image of the right eye is lower, paralysis of the left superior oblique if the image of the right eye is higher.

(b) If the diplopia is *crossed*, paralysis of an *inferior rectus* is indicated: the right inferior rectus if the image of the right eye is lower, the left inferior rectus if the image of the right eye is higher.

This table would be entirely satisfactory if paralysis of the oblique muscles always produced homonymous or simple diplopia, and paralysis of the superior and inferior rectus muscles always caused heteronymous or crossed diplopia. This, however, is not the case, and it is well known, as has already been pointed out, that the diplopia from paresis of the obliques may be crossed, and that from paresis of the superior and inferior recti homonymous. Hence Duane insists that paralysis of the obliques and of the superior and inferior recti should be diagnosticated from the behavior of the vertical diplopia.

This author divides the twelve muscles moving the two eyes into *three groups* of four each: four moving the eye laterally, four moving them up (elevators), and four moving them down. Each group is divided into *two pairs*. Thus, the

four *laterally acting muscles* are divided into (a) a pair of *right turners* (right externus and left internus), and (b) a pair of *left turners* (right internus and left externus). The four *elevators* are divided into (a) a pair of *right-hand elevators* (right superior rectus and left inferior oblique) and (b) a pair of *left-hand elevators* (right inferior oblique and left superior rectus). The four *depressors* are divided into (a) a pair of *right-hand depressors* (right inferior rectus and left superior oblique) and (b) a pair of *left-hand depressors* (right superior oblique and left inferior rectus).

In order to assist in the diagnosis of the affected muscle the following table has been constructed by Dr. Duane, which he permits the author to insert:

TABLE OF DIPLOPIA IN OCULAR MUSCLE PARALYSIS, ACCORDING TO DUANE.

A. There is a lateral (*i. e.*, a homonymous or crossed) diplopia which increases markedly as eyes are carried laterally (to right or left). A laterally acting muscle is paralyzed.

(a) Diplopia increases in looking to the right (= paralysis of a right turner).

Diplopia homonymous: Paralysis of right externus.

Diplopia crossed: Paralysis of left internus.

(b) Diplopia increases in looking to the left (= paralysis of a left turner).

Diplopia crossed: Paralysis of right internus.

Diplopia homonymous: Paralysis of left externus.

B. There is a vertical diplopia which increases in looking up. An elevator is paralyzed.

(a) Vertical diplopia increases in looking up and to the right (= paralysis of a right-hand elevator).

Diplopia left (*i. e.*, image of right eye above): Paralysis of right superior rectus.

Diplopia right (*i. e.*, image of left eye above): Paralysis of left inferior oblique.

(b) Vertical diplopia increases in looking up and to the left (= paralysis of a left-hand elevator).

Diplopia left (*i. e.*, image of right eye above): Paralysis of right inferior oblique.

Diplopia right (*i. e.*, image of left eye above): Paralysis of left superior rectus.

C. There is a vertical diplopia which increases in looking down. A depressor is paralyzed.

(a) Vertical diplopia increases in looking down and to the right (= paralysis of a right-hand depressor).

## 586 Movements of the Eyeballs and their Anomalies

Diplopia right (*i. e.*, image of right eye below) : Paralysis of right inferior rectus.

Diplopia left (*i. e.*, image of left eye below) : Paralysis of left superior oblique.

(*b*) Vertical diplopia increases in looking down and to the left (= paralysis of a left-hand depressor).

Diplopia right (*i. e.*, image of right eye below) : Paralysis of right superior oblique.

Diplopia left (*i. e.*, image of left eye below) : Paralysis of left inferior rectus.

To illustrate the practical working of the table the following example is quoted : The patient with a red glass before the right eye is directed to observe a candle which is moved in all directions in his field of fixation. If the patient has single vision when he looks down, but has vertical diplopia when he looks up, paralysis of an elevator is inferred. The vertical diplopia increases greatly when he looks up and to the right, and diminishes to almost nothing when he looks up and to the left. The paralysis must affect a right-hand elevator (right superior rectus or left inferior oblique). The red image is higher (left diplopia = right eye below). The paralysis must affect the right superior rectus. If it had been the left inferior oblique, the red image would have been the lower ; and if it had been either the right inferior oblique or the left superior rectus, the vertical diplopia would have increased not when the patient looked up and to the right, but when he looked up and to the left.

**Causes.**—The lesion which causes paralysis of an ocular muscle may have an *intracranial*, *orbital*, or *peripheral* situation. If intracranial, it may be *cerebral*—that is, *cortical*, *nuclear*, or *fascicular* in situation, or else *basal*.

Among the conditions residing in the orbit which produce paralysis of the extra-ocular muscles, the so-called *orbital palsies* are cellulitis, tenonitis, periostitis, tumors, metastatic carcinomatous nodules (Elschnig), hemorrhage, fracture, and affections of the sinuses.

Syphilis is the most frequent cause of extra-ocular muscle palsies, constituting about one-half of the cases—according to Alexander, 59.4 per cent. The resulting paralysis may be due to an inflammation or gummatous change affecting the nerves at the base of the brain or in the orbit, or it may be central in origin from disease of the nuclei of the nerves or of the brain in their immediate vicinity, or from lesions in the third ventricle, the aqueduct of Sylvius, or the fourth ventricle.

Syphilitic paralysis is generally one of the later manifestations, but it has been noted as early as the sixth month after the primary infection, particularly in the form of ptosis. In rare instances paralysis of the ocular muscles results from inherited syphilis (Graefe, Nettleship, Lawford).

Other causes, some of which at times occasion *central*—that is, *nuclear*—lesions, and at other times act *peripherally*, are rheumatism, gout, diabetes, whooping-cough, influenza, herpes zoster, and certain toxic agents—for example, lead, alcohol, tobacco, gelsemium, conium, chloral, carbonic acid, and fish- and meat-poisoning (ptomain-poisoning, toxalbumins, botulism, and allantiasis).

The external rectus is the muscle most frequently affected by rheumatism and diabetes and often by influenza. So-called rheumatic palsies, as Mauthner has pointed out, may be followed years after by tabes of the cord, disseminated sclerosis, or paralytic dementia. Although diphtheria usually affects the ciliary muscle, it may attack one or more of the external muscles, generally the external rectus. The condition may be bilateral. Rarely complete ophthalmoplegia occurs.

The ocular manifestations of fish- and meat-poisoning are usually paresis or paralysis of accommodation and paralytic ptosis. The external muscles may be affected. The lesions are probably usually nuclear.

The diseases and lesions which attack the nerves at the base of the brain, and thus occasion the so-called *basal palsies*, are hemorrhage, meningitis, both simple and tubercular, particularly the latter, abscess—for example, in connection with middle-ear disease, aneurysm, diseases of the cavernous sinus, syphilis, and tumors.

A number of paralyzes of the external ocular muscles are seen in connection with locomotor ataxia, parietic dementia, disseminated sclerosis, and bulbar paralysis. Tabetic paralysis is often transitory in its nature; it may be associated with the pupillary changes characteristic of this affection. Relapses are frequent. Paralyzes of the orbital muscles of *cerebral* origin may result from degenerative, hemorrhagic, or neoplastic lesions affecting the cortex of the brain, the cortico-



## 588 Movements of the Eyeballs and their Anomalies

peduncular region, the nuclei of the nerves, or the nuclear fibers.

*Injuries* may cause ocular muscle palsy—for example, the muscle may be torn or the nerve-trunk divided, or there may be paralysis owing to periostitis of the orbit, fracture of the orbital walls or base of the skull. The palsy may develop secondarily from basal meningitis, abscess, or nuclear degeneration.

A number of cases of *congenital palsy*, especially of the external rectus, have been observed, which in some instances may have been due to a lesion affecting the nucleus of the implicated nerve during intra-uterine life. In addition to this there are anomalies of the external muscles depending upon their abnormal insertion. Entire absence of a muscle has been noted. Occasionally cases of orbital muscle palsy have been attributed to various so-called *reflex disturbances*.

**Recurrent Oculomotor Paralysis** (*Ophthalmoplegic Migraine*—Charcot).—The symptoms of this comparatively rare affection are violent unilateral headache, nausea, vomiting, slight fever, and usually paralysis of the third nerve on the same side as the pain. The attacks come in periodic crises, and the disease may last from several days to long periods of time. Occasionally the paralysis remains permanent. The lesion is probably one involving the root of the third nerve.

**Retraction Movements of the Eyeball Associated with Congenital Defects in the External Ocular Muscles.**—According to Wolff, a retraction movement—that is, a drawing backward of the eyeball into the orbit when an attempt is made to turn the affected eye inward—is a congenital condition. There is always partial or complete paralysis of the external rectus of the retracted side. These cases have been explained by assuming a faulty insertion of the internal rectus, or on the theory that the eyeball is fixed on the outer side by a paralyzed external rectus, and hence the internal rectus, instead of adducting the eye, draws it backward into the orbit.

Duane has observed in these cases a spasmodic action of the obliques which produces a marked upward or downward

## Relative Frequency of Paralysis of Orbital Muscles 589

deflection of the eye when an attempt is made to rotate it inward.

**Divergence Paralysis.**—This condition manifests itself by homonymous diplopia and convergent strabismus when the eyes are fixed upon a distant point. As the test-object approaches the patient, and especially on lateral fixation, there is diminution of the convergent strabismus and the diplopia, and finally a point may be reached where there are single vision and orthophoria, while within this limit there may be exophoria. Cases of this character have been described as secondary to an abducens paralysis, and also ascribed to spasm of convergence and to paralysis of a supposed divergence center. Berry believes the correct diagnosis of this condition to be *spasm of convergence* and not paresis of divergence.

It is often difficult to ascertain whether the paralysis is *central* or *peripheral* in its origin. The differential diagnosis must be made by examining into the completeness of the paralysis and the existence of complications or associated symptoms. Peripheral palsies are more apt to be isolated and complete; those of central origin are often associated with other symptoms indicative of intracranial mischief. Some information is obtainable by noting the effect of prisms upon the double images. Graefe pointed out that it is almost impossible to fuse the images when the palsy which originated them is of central origin.

### **Relative Frequency of Paralysis of the Orbital Muscles.**—

Paralysis of the abducens (external rectus) is met with most frequently, the next in order of frequency being unilateral paralysis of the oculomotor. After these come paralysis of the superior oblique, inferior rectus, superior rectus, internal rectus, and inferior oblique. However, statisticians differ exceedingly on these points—*e.g.*, Duane ranks the superior rectus next to the external rectus.

**Prognosis.**—The prognosis depends upon the cause of the palsy. Some cases of peripheral paralysis, especially those depending upon syphilis and rheumatism, are readily amenable to treatment; in others, not only is the paralysis incurable, but the lesion which creates it may be a fatal one. Hence the

## 590 Movements of the Eyeballs and their Anomalies

importance of trying to ascertain the character and situation of the lesion which produces the palsy.

**Treatment.**—In syphilis the usual remedies are applicable, and in many instances the best results follow very large doses of iodid of potassium. Massive doses are often tolerated, and even if the paralysis has existed for a long time, cure may result. In rheumatism, in addition to iodid of potassium, salicylic acid is useful, especially in the earlier stages. It may be given, not in combination, but at the same time as the iodid. The various causes which have been mentioned furnish the indications for other treatment. In suitable cases strychnin seems to do good, or ascending doses of tincture of nuxvomica.

The great annoyance which is produced by the double images may be remedied by covering the affected eye with a piece of ground glass, which is mounted in a spectacle-frame. If the patient is ametropic, his correcting lens for the opposite eye may be placed in the same frame.

Sometimes prisms may be worn which fuse the double images. The rules for adjusting prisms are given on page 615.

Mechanical treatment has been suggested by Michel, and has been very extensively tried in this country by Bull. The conjunctiva is seized near the insertion of the affected muscle with forceps, and the eyeball is drawn forcibly, as far as possible, beyond the ordinary limit of contraction, and then back again. The eye is first cocaineized. The movements are made daily, and continued for about a minute at a time.

Electricity may be tried, the great difficulty being in passing the current through the muscle. Ordinarily one pole—the cathode—is placed upon the closed lid, while the other is put upon the temple. Usually a current of more than 3 milliamperes is unbearable. This is especially true if the pole is placed directly upon the sclera, the eye first having been cocaineized. Very disagreeable flashes of light will usually take place if a current of more than 1 or  $1\frac{1}{2}$  milliamperes is employed. If faradism is tried, a very weak current should be selected.

Finally, after all other means have failed, tenotomy has been resorted to, or else advancement of the paralyzed muscle. In many cases advancement of the paralyzed muscle and tenotomy of the antagonist are necessary. The best results are obtained in the lateral muscles. In case an injured muscle—that is, one torn from its insertion—should be seen soon after the accident, it would be proper to find the ends of the divided muscle and stitch them together.

**Ophthalmoplegia.**—Although the term ophthalmoplegia might with perfect propriety be used to describe all the ocular muscle palsies, it is generally reserved for that class of paralyzes of the orbital muscles due to disease of the nuclei of the third, fourth, and sixth nerves. Ophthalmoplegia may be divided into *acute ophthalmoplegia* or *acute nuclear palsy*, and into *chronic ophthalmoplegia* or *chronic nuclear palsy*. When it so happens that the intra-ocular muscles alone are affected, the term *ophthalmoplegia interna* is sometimes employed, and when the external muscles alone are affected, the term *external ophthalmoplegia*. When both sets of muscles are involved, the term *total ophthalmoplegia* is appropriate.

*Acute ophthalmoplegia* is characterized by a rapid paralysis of all ocular muscles, often associated with fever and convulsions. Many of the cases have proved to be fatal. They occur with hemorrhage in the region of the nuclei, or as an acute hemorrhagic polio-encephalitis, the primary cause being tuberculosis, syphilis, ptomain-toxemia, or poisoning from alcohol or sulphuric acid. Acute ophthalmoplegia may be associated with acute poliomyelitis, with bulbar palsy, or with facial palsy, and has been confounded with an acute peripheral neuritis of the orbital nerves. Certain poisons—for example, nicotin, lead, and carbonic acid—may cause an ophthalmoplegia which is not fatal, or, at least, not necessarily fatal, and the same is true of one type which is seen with certain constitutional diseases—for instance, diabetes, syphilis, and influenza. *Transient bilateral ophthalmoplegia* has been described, the symptoms developing rapidly and disappearing completely after one or two months.

*Chronic ophthalmoplegia* is characterized by loss of power

## 592 Movements of the Eyeballs and their Anomalies

in one or more eye muscles, which may gradually increase until every muscle is paralyzed. Sometimes the levator escapes; indeed, ptosis may be absent. The disease may be *stationary* or *progressive*. It is not always symmetric; it may be unilateral. Chronic ophthalmoplegia may follow an acute palsy, the lesions of which have started chronic degenerative changes; it may appear as a *congenital* and occasionally *hereditary* affection, usually in the form of bilateral ptosis, and it is seen in association with locomotor ataxia, parietic dementia, progressive muscular atrophy, chronic bulbar paralysis, and disseminated sclerosis. The underlying constitutional condition may be syphilis and sometimes tuberculosis. The disease is essentially chronic, and may last for years. It is more common in males than in females, and is more serious in children than in adults.

If the intra-ocular muscles escape, which is not always the case, there is strong presumptive evidence that the origin of the trouble is nuclear, but, as Mauthner has pointed out, it is not a characteristic sign. Siemerling concludes that nuclear disease may be inferred from external ophthalmoplegia, if it is not maintained that nuclear palsy must manifest itself as an external ophthalmoplegia. In general terms the lesions are degenerative, inflammatory, or hemorrhagic. According to Siemerling, the pathologic states underlying progressive paralysis of the ocular muscles may reside in nuclear disease, in degeneration of the muscles and of the nerve-trunks, the nuclei being intact, and in interruption of the conducting power of the intramedullary roots, muscles, nerve-trunks, and nuclei being uninvolved.

**Treatment.**—In many instances this is wholly without result. If syphilis is present, the usual remedies are applicable, especially iodid of potassium in massive doses.

**Associated Ocular Paralysis.**—Sometimes the eyes cannot make certain movements in which they are usually associated, although the directing power of the muscles may be unimpaired when they exercise their function in a different association. In other words, there is paralysis of movement and not of the muscles supplied by a given nerve.

Thus the internal recti may be unable to draw the eyes together in the act of convergence, although they may act normally in helping to move the eyes from side to side; or there may be loss of the synchronous lateral movement of the external rectus of one eye and the internal rectus of the other (*conjugate lateral paralysis*) although convergence is normal; or the vertical movement may be lost in each eye. Lesions affecting the centers for combined movements may produce such phenomena; symmetric disease of the nuclei of the affected nerve explains some cases in which the upward and the downward movement are lost.

In apoplexy, if the head is drawn from the paralyzed side and the eyes are also turned to the sound side, the condition is called "*conjugate deviation of the head and eyes*." The rule is, according to Prevost, that in lesions of the hemisphere the eyes are turned toward the lesion and away from the paralyzed side, but in lesions of the mesencephalon they are turned away from the lesion and toward the paralyzed side. Should there be unilateral convulsions, with the eyes turned toward the convulsed side, there is an irritative lesion in the hemisphere, but if the head and eyes are turned away from the convulsed side, there is an irritative lesion in the mesencephalon (Landouzy).

**Paralysis of the Internal Ocular Muscles.**—Under the general term *cycloplegia* are included the cases of paralysis of the ciliary muscle. These may or may not be accompanied with dilatation of the pupil.

If the ciliary muscle is paralyzed, the chief symptom is loss of accommodation, precisely as it occurs after the instillation of a mydriatic. The loss of accommodation may be *complete* or it may be *partial*; that is, one or more diopters of the entire amount which is normal at the patient's time of life may still remain. After the fiftieth year it is difficult to detect cycloplegia.

It occurs from a lesion in the trunk of the oculomotor nerve or in the anterior part of its nucleus (consult also oculomotor palsy and ophthalmoplegia). Unilateral cycloplegia is said to be possible under the influence of disease

## 594 Movements of the Eyeballs and their Anomalies

of the ciliary ganglion. A very common cause of double paralysis of the ciliary muscle is diphtheria. Cycloplegia also is occasioned by spinal disease, by diabetes, and frequently by syphilis, especially if accompanied by palsy of the sphincter of the iris. Paresis of the ciliary muscle is common after certain fevers—for example, typhoid fever.

Under the general term *iridoplegia* are included the conditions which occur when there is loss either of the direct or of the associated action of the iris, due to paralysis of its sphincter. The chief symptom is connected with changes in the action of the pupil. The condition may or may not be accompanied with paralysis of the ciliary muscle. The various pupillary changes have been discussed in Chapter II., page 63. Consult also page 591.

### **Concomitant Strabismus or Squint: Heterotropia.**—

This form of strabismus is characterized by the power of the squinting eye to follow the movements of the other eye in all directions, the angle of squint always maintaining the same size.

**Varieties of Concomitant Strabismus.**—The chief deviations of squinting eyes, as already given, are: *convergent strabismus*, or *esotropia*; *divergent strabismus*, or *exotropia*; and *vertical strabismus*, or *hypertropia*. Concomitant squint may be *periodic* or *constant*. The latter variety is divided into *monocular squint*—that is, under ordinary circumstances the same eye always deviates when the other eye is used for fixation, and *alternating squint*—that is, either eye is used indifferently for fixation. Lateral squint is usually associated with upward deviation. It is probable that at first squint is generally periodic, but with repeated recurrences, as Priestley Smith expresses it, the suppression of the deviating image becomes confirmed, and the squint becomes continuous. The average age for squint to begin is three and four-tenth years, although it is often noticeable during the first year of life. Squints occurring after five years are apt to be alternating, in which case excellent vision exists in each eye.

**Causes of Concomitant Strabismus.**—The etiology of strabismus has occasioned much discussion, and even at this time is not a settled question. In general terms, the factors which

have been considered important in the causation of squints may be summarized as follows :

1. Disturbance of the relation between accommodation and convergence by errors of refraction.
2. Disparity in the length, thickness, and tension of opposing muscles.
3. Inequality in the vision of the two eyes, or amblyopia of one eye, which removes the natural stimulus of diplopia to exact convergence.
4. Disturbances of innervation and defective development of the fusion faculty.

These causes of squint are somewhat elaborated in the succeeding paragraphs.

1. *Disturbances in the Relations of the Functions of Accommodation and Convergence.*—The relation between these two functions has been previously described (page 51). Some latitude of movement is possessed by each function separately ; but a limit to the independent exercise of either function exists, beyond which neither function can operate alone. Thus, a hyperopia of 6 D would require an accommodation of 6 D to neutralize it, the visual lines being parallel. This is rarely possible ; some meter-angles of convergence will usually accompany the accommodative effort. The point of convergence is then nearer than the point accommodated for, constituting a convergent squint. Hyperopia is, therefore, frequently accompanied by convergent squint.

In contrast to this, a myope of 10 D requires 10 meter-angles of convergence to see at his far point of vision—that is, the point at which he can see with relaxed accommodation. This is not usually possible, because the enormous convergence necessary to see at this point is too severe a strain ; consequently, the visual lines intersect at a greater distance than the point for which they are accommodated, and binocular vision is abandoned. The eyes, left to the preponderating forces, assume the direction seen during sleep and deep anaesthesia—viz., divergence. Myopia is therefore frequently accompanied by divergent squint.

Sometimes individuals possess or acquire unusual power in



## 596 Movements of the Eyeballs and their Anomalies

developing one or other of these two functions. Thus, the hyperope may develop his accommodation sufficiently to equalize the disparity in the refraction and thus avoid squinting. The myope may also develop his convergence beyond the usual amount so as to prevent divergence. Hence all hyperopes do not have convergent squint; neither do all myopes have divergent squint.

2. *Disparity in the Length, Thickness, or Tension of Opposing Muscles.*—The four rectus muscles are arranged in two pairs, and each muscle of a pair is antagonistic to the other. When one muscle contracts its opponent should relax, and the degree of traction in the muscles of each pair should be equal. The same equality should exist between the corresponding muscles of the two eyes.

A longer or thinner muscle in the corresponding members of each pair would result in a limitation of the movement of the ball in the direction of these muscles, and a tendency in the passive condition for the eyeballs to deviate in the direction of the opponents. The opponents under these circumstances are shorter or thicker, or both. After the equilibrium has been disturbed, the eyeballs, yielding to the stronger muscles, deviate in the direction of the stronger muscles, which become still stronger by their tonic contraction, while their antagonists become weaker by being elongated. The internal recti in convergent squint are often found broad and fleshy, while in divergent squint the external recti are hypertrophied in a similar manner. According to Schweigger, the tension relation of the muscles gives in most cases the impetus for the development of strabismus. In hyperopia there is frequently a preponderance or strong tension of the interni; in myopia, of the externi; therefore convergent strabismus is common in hyperopia, divergent strabismus in myopia.

3. *Inequality in the Vision of the Two Eyes, or Amblyopia of One Eye, Which Removes the Natural Stimulus of Diplopia to Exact Convergence.*—Amblyopia of the squinting eye is present in a large proportion of the cases of concomitant convergent strabismus, or, more accurately, the amblyopia of the squinting eye exceeds that of the other. Whether this

amblyopia is a cause or a consequence of the squint has given rise to two theories. According to one theory, advocated by Donders and others, the squint causes the amblyopia which depends upon a loss of vision due to habitual suppression or to lack of use of the squinting eye—*amblyopia ex-anopsia*—or, according to Hirschberg's terminology, *amblyopia exalepsia*. According to the other theory, advanced by Schweigger, and which is the more satisfactory of the two, the amblyopia is a congenital defect which precedes and causes the squint. Priestley Smith points out that all eyes are amblyopic at birth, and reach the normal standard of vision only after several years. If strabismus is established before this standard is attained, further visual progress of the squinting eye is likely to be hindered or even arrested.

Ophthalmoscopically these amblyopic or so-called "neglected eyes" may be entirely normal, or, as Noyes has stated, there may be at times distinct changes in and around the nerve-head and in the macula. Central scotomas and contraction of the visual field are sometimes demonstrable, as the author has shown, and under such circumstances these eyes are not susceptible of improvement in visual acuity.

An amblyopia which removes the stimulus of diplopia to exact convergence may also include cases in which the visual acuity is diminished by refractive differences in the two eyes, one eye being greatly inferior to its fellow by reason of a high degree of hyperopia or myopia, with or without astigmatism, by opacities in the media of one eye (especially corneal opacities), by congenital cataract, and by complete blindness. The failure to recognize diplopia causes the visual axes to vary considerably either toward convergence or divergence, without appreciation of this on the part of the patient. If the eyes are hyperopic, they are apt to converge; if myopic, to diverge. Numerous cases of squint exist without amblyopia, and the refraction of both eyes may be equal.

4. *Disturbances of Innervation.*—According to Hansen Grut, "convergent strabismus originates and continues as the result of an *innervation* which effects in the interni a shortening exceeding in amount that which is desirable. Divergent stra-

## 598 Movements of the Eyeballs and their Anomalies

bismus is the expression for a relaxation of convergence-innervation, which permits the eye to take up its anatomic position of rest." According to Priestley Smith, "convergent strabismus is a disorder of innervation in which the visual centers fail to control the act of convergence, which is degraded and becomes automatic. It is excited by the act of accommodation and is excessive because uncontrolled. The failure of control depends largely upon faulty development of the visual apparatus. Hyperopia, when of considerable degree, predisposes to strabismus by demanding an abnormal effort of control. The disorder is confirmed and perpetuated by suppression of the function of the squinting eye."

Claude Worth, although willing to admit that muscular defects, refractive errors, and amblyopia may be the immediate excitants of convergent strabismus, believes they are powerless unless there is a defective development of the *fusion faculty*, which he regards as the one essential cause of squint.

A predisposition to strabismus may arise on account of the size and shape of the eyeball and orbit. A narrow, horizontal diameter of the face might predispose to convergent strabismus, or an unusually broad diameter to divergent strabismus. These conditions may coexist with hyperopia and myopia. A very short eyeball, flattened in its anteroposterior direction, by its greater facility of movement would render convergence easier; the opposite condition—namely, elongation of the anteroposterior axis of the eyeball—would render this movement more difficult. An unusual value of the *angle gamma* might create a disposition to squint by disturbing the relation between convergence and accommodation.

**Single Vision in Concomitant Strabismus.**—Diplopia is rarely noticed in concomitant convergent strabismus, because the eye involuntarily suppresses the false image, or else has learned to disregard it.

Suppression of the image is not, however, habitually permanent, and many patients can be made conscious of diplopia if a red glass or cobalt glass is placed before one eye and a prism before the other. When the squint is very large, it

may be necessary to correct the greater part of it with prisms before diplopia is manifest. If prisms and the red glass fail, Schweigger's test is as follows: A flame is placed to one side of, and behind, the squinting eye, and its image is thrown into this eye with a plane glass held close to it. When the reflex reaches the center of the pupil, the patient sees it and can describe its relation to the image of another flame observed by the fixing eye at a distant point. With high degrees of amblyopia it may be impossible to produce diplopia.

In concomitant divergent squint, especially of low degree, and in the convergent strabismus of myopes diplopia is not uncommon; also in moderate degrees of convergent strabismus and in the residual squint after tenotomy.

Sometimes after operation, as was first noticed by Von Graefe, the *diplopia* is anomalous or *paradoxical*, as it is called—that is, there is crossed diplopia with convergent squint. Javal has observed and studied the same phenomenon in strabismic patients upon whom no operation has been performed. It has been explained on the theory that there has been developed in the squinting eye a spot identical with the macula lutea of the straight eye, or that there has been developed what has been named a *vicarious fovea*. According to Tscherning, in certain cases of strabismus a period may be reached after operation when the patient localizes with reference both to the new and the old fovea, the result being *binocular triplopia*, a name given by Javal to the phenomenon. Verhoeff thinks paradoxical diplopia “is due, not to the development of a new system of corresponding points, but to an absence of any such system whatever, so that when diplopia is produced, each eye localizes its image with regard to itself alone and hence more or less correctly.”

**Measurement of Strabismus.**—I. Squint may be measured approximately by the deviation inward of the pupil of one eye while the other eye fixes an object. The pupil being situated 10.5 mm. in advance of the center of rotation, its deviation inward or outward, measured on a rule, represents the tangent of the angle of the squint. A deviation of 1 mm. represents a squint of  $5^\circ$ . For this purpose an ordi-

## 600 Movements of the Eyeballs and their Anomalies

nary rule divided into millimeters may be employed, or a specially devised instrument curved to adapt itself to the curve of the eyeball and known as a *strabisometer*.

If diplopia is present, the extent of a squint may be determined by what Swanzy calls the "Method by Tangents," and which he describes as follows:

Upon a wall of the consulting-room, in a horizontal line, and so as to be on a level with the eyes of the patient, who is about 3 meters from the wall, are permanently marked out tangents of angles of  $5^{\circ}$  each, as seen from the place where the squinting eye is. Exactly opposite to the squinting eye is  $0^{\circ}$ , while toward the right and left the points are marked up to  $45^{\circ}$  or more. The flame of a candle being held at  $0^{\circ}$ , and one eye of the patient being covered with a red glass, he is called on to indicate the position of the image belonging to the squinting eye, and the number on the wall which corresponds to this gives the angle of the strabismus.

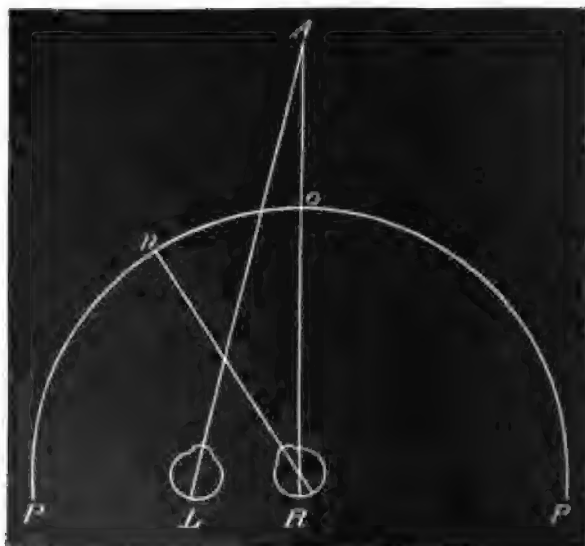


FIG. 184.—Measurement of squint with a perimeter.

Under these circumstances the degree of prism necessary to fuse the double images may be used to measure the squint.

2. *Angular Method*.—The perimeter may be employed to measure squint with great accuracy. Landolt thus describes the method:

The deviating eye  $R$  is placed at the center of the graduated arc of the perimeter  $PP$ , the arc lying on the plane of the deviation. The patient is then required to fix with *his two eyes* a distant object,  $A$ , situated at the central radius  $R o A$ . This is the direction which the deviating eye should have in the normal condition. The point  $n$ , to which the eye in reality is directed, should now be determined; the angle  $ORn$ , formed by the deviating visual line  $n$ , with the normal line of fixation  $A o R$ , is the *angle of the strabismus*. In order to obtain this direction (*i. e.*, the point  $n$  at which the eye is directed), it would be necessary only to determine the visual axis. As this is not an easy matter, it is sufficient in practice to be contented with the optical axis; this differs from the former only by the angle gamma, which, in comparison with the large angle of the strabismus, may be neglected. The flame of a candle is moved along the arc of the perimeter until its reflexion is in the center of the pupil. This will occur when the flame is at  $n$ . The optical axis has now been found, and the size of the angle of strabismus may be read off.

**Treatment of Concomitant Strabismus.—A Convergent Concomitant Strabismus.**

1. *Spectacle Treatment*.—Glasses which neutralize the refractive error should be ordered for every case of convergent concomitant squint after the use of atropin has thoroughly paralyzed the functions of the ciliary muscle, and, moreover, these correcting lenses should be adjusted as soon as it is safe for the child to wear spectacles.<sup>1</sup> In the majority of cases the refraction is hyperopic and is often associated with considerable degrees of astigmatism. There is no difficulty in estimating exactly the proper lenses by means of retinoscopy. In very young children good results may follow the prolonged use of a weak solution of atropin, which may be instilled in both eyes or only in the fixing eye. By this means the accommodation is paralyzed and the abnormal stimulus to convergence which results from overaction of the ciliary muscle is removed.

2. *Educative Treatment*.—This includes occlusion of the

<sup>1</sup> Lang and Barrett, from an examination of 102 cases of convergent strabismus in which glasses had been used during periods of from six to twenty-four months, conclude that the spectacle treatment produces a rapid and complete cure in about 10 per cent. of the cases; in 33 per cent. the cure continues so long as the spectacles are worn. The effect of the treatment is in direct ratio to the youth of the patient.

## 602 Movements of the Eyeballs and their Anomalies

eye by means of a *shade* or *pad*, *bar reading*, and *orthoptic training*.

(a) *Occlusion of the Fixing Eye*.—The sound eye should be covered with a shade or bandage, not so much with the hope of improving the acuity of vision of the deviating eye, but, as Priestley Smith has said, to compel it to use such vision as it has to promote fixation, and to prevent or stop the habit of suppression. If the child wears spectacles, as it should, a blinder of gutta-percha may readily be adjusted on the lens in front of the fixing eye. If the vision of the squinting eye is very imperfect, it is permissible during this treatment to wear the patch on this eye instead of the sound one for a few hours each day, but both eyes should not be allowed to be uncovered at the same time.

(b) *Orthoptic Training*.—This consists of the establishment of diplopia and training the eyes to fuse the double images, and is a method of treatment of squint especially advocated by Javal. It is particularly suited to moderate degrees of strabismus and to instances of residual squint after operation. It requires considerable care and patience properly to carry out the details. In order to educate the fusion faculty the *stereoscope* should be employed. The patient's ametropia having been fully corrected, the exercises may be performed, according to the method given by Landolt, as follows :

In an ordinary box-stereoscope, in the place of "views," two objects of some very simple shape are introduced—for instance, two vertical lines, one above and the other below the same horizontal line. These two lines, which may be brought toward, or removed farther from, each other at will, are placed at a distance about equal to that between the two eyes. Under such circumstances their fusion into a single vertical line necessitates parallelism of the lines of fixation. This parallelism is generally possible only in the absence of any accommodative effect. Hence the sight-holes of the stereoscope are provided with + 6 D lenses (the length of the ordinary stereoscope being 16 cm.), which permit the subject to see at the distance of the objects without exercise of the accommodation.

The majority of patient's do not succeed in fusing the images when their eyes are directed in a parallel direction. These latter generally show a certain convergence. The patient is then taught to find the distance between the two objects, which is requisite for

the fusion of their images. When this is accomplished, the two objects are gradually separated more and more in successive sittings, until fusion is effected without the least convergence.

When binocular vision is obtained, with parallelism of the lines of fixation, which is equivalent to binocular vision at a distance, an attempt should be made to realize it for a point which requires a certain degree of convergence. To provoke a convergence of one meter-angle, the objects are brought together through a distance varying with the base line, the average being about one centimeter. In order to make the patient furnish an amount of accommodation equivalent to this amount of convergence, the strength of the convex lens is diminished one diopter. The trials are continued in this way until the two objects are brought on a vertical line. At this moment they require, for their binocular fixation, a convergence of 6 meter-angles and an accommodation of 6 D. An emmetrope would, therefore, have to remove the glasses from the stereoscope and see with the naked eye; an ametrope would require simply the correction of his refractive defect.

If the angle of squint is very great, both eyes cannot look at the same time into an ordinary stereoscope, and therefore a number of excellent instruments have been devised which can be adapted to the angle of squint. Kroll's orthoptic exercises, which consist of colored plates arranged by Perlia placed in a suitable stereoscope, are satisfactory. Mr. C. Worth,<sup>1</sup> who gives an admirable description of the orthoptic treatment of convergent squint in young children, has devised a special instrument for this purpose to which he gives the name *amblyoscope*. The illumination of the object looked at by the deviating eye may be increased in order to reinforce its visual impressions, as in Landolt's new stereoscope.

These methods to overcome the defective development of the fusion-faculty should be faithfully tried in spite of the trouble which their use entails. Certainly the reestablishment of binocular vision under these circumstances is worth every effort.

(c) *Bar Reading (Controlled Reading of Javal)*.—A pencil, or, as Priestley Smith suggests, a thin strip of metal, is held midway between the eyes and the book which they regard. Reading can then take place without interruption only if both eyes are employed. Priestley Smith describes the exercises

<sup>1</sup> *Trans. Ophth. Soc. U. K.*, vol. xxi., 1901, p. 245.



## 604 Movements of the Eyeballs and their Anomalies

as follows: "When the patient's fixing eye reaches that portion of the line which is hidden from it by the bar, he must use his other eye. Then the fixing eye is covered for a moment with a screen. Next, the patient is taught to occlude it for himself by a momentary closure of the lids. Soon he will be able to travel along the line with only a slight hitch where he closes the better eye, and at last he will read smoothly, keeping both eyes open." The method is chiefly effective when practised in conjunction with the use of the shade—that is, the shade covers the fixing eye and it is uncovered only for the purpose of bar reading; and this should be practised as much as possible. Indeed, according to Javal, the exercises must be continued for months, but there seems no doubt that they are efficient aids in the recovery of binocular vision. It need hardly be stated that the exercises are not suited to very young children. They are valuable in the residual squints after operation.

3. *Operative treatment* consists of tenotomy of one or both internal recti, with or without advancement of the externus (see page 723). An operation is usually inadvisable before the sixth year, and should never be undertaken until the refractive error has been fully corrected and glasses have been worn for at least two months. The exercises previously described should in the mean time be employed.

Preceding the operation the surgeon should estimate the degree of the squint, the presence or absence of diplopia, the ability of the patient to describe the relative positions of the double images, if they exist, the visual acuity, and the power of the external recti. Schweigger advises gymnastic exercise of the muscles by alternately turning the eyes to the right and left as a useful preliminary to the operation for squint.

There is much difference of opinion in regard to the operations which should be practised for the relief of convergent strabismus, and each case must be carefully studied before a correct decision can be reached. In general terms the author has secured satisfactory results by proceeding as follows: In small squints ( $15^{\circ}$  to  $20^{\circ}$ ) tenotomy of the internal rectus of the deviating eye, especially if this eye is not seriously ambly-

opic, will frequently suffice. It is proper to allow a squint of from  $3^{\circ}$  to  $5^{\circ}$  to remain after the tenotomy, otherwise divergence may be the ultimate result. If the deviation is greater than  $20^{\circ}$ , a single tenotomy is rarely sufficient, and what the best procedure should be depends upon whether the surgeon deals with a case of *alternating* or *monocular* strabismus. In alternating strabismus good results follow bilateral tenotomy. Should this not prove sufficient and should a deviation remain in excess of that which is controlled by glasses and exercises, the externi may be advanced. If the squint is monolateral and the angle exceeds  $30^{\circ}$  and the deviating eye is amblyopic, it is practically always necessary to combine tenotomy with advancement of the external rectus, and generally necessary, in addition to the advancement of the external rectus of the deviating eye and tenotomy of its internus, to make a small tenotomy of the internus of the opposite eye. A subsequent tenotomy of the superior rectus is sometimes needed to correct an upward deviation. In marked cases it may be necessary to advance both externi and divide both interni. With bilateral tenotomy, according to the method of Panas, the author's experience has been limited. The primary effect of the operation seems to be very good. With Dr. Landolt's method of bilateral free advancement of the external recti to the exclusion of tenotomy of the internal recti his experience has as yet been too limited to speak with authority. Certainly it would seem to be an ideal operation, because the rotations of the globe are not limited, and he has seen in Dr. Landolt's clinic the most admirable results achieved by this distinguished surgeon. Free division of the tendinous insertion of the interni and the surrounding capsular attachments is *never advisable* and almost sure in subsequent years to lead to divergence. After operation either both eyes should be bandaged, as they must be after advancement until the sutures are removed, or both eyes should be unbandaged and the patient from the first directed to wear his correcting glasses. (For the methods of performing tenotomy and advancement see page 723.)

*B. Divergent Concomitant Strabismus.*—The treatment of this form of concomitant squint includes the correction of the

## 606 Movements of the Eyeballs and their Anomalies

error of refraction with suitable glasses, training convergence, and operative measures.

(a) *Glasses* which neutralize the refractive error (most commonly myopia or myopic astigmatism) should be adjusted according to the rules which are given in the chapter devoted to the measurement of abnormal refraction. Moderate degrees of divergent deviation may often be favorably influenced by prismatic exercises (see page 614).

(b) *Operative measures* depend entirely upon the degree of the deviation, the vision in the diverging eye, and the cause of the difficulty. When true divergent strabismus exists, it is usually necessary to perform an operation to correct it. This may be either tenotomy of one or both externi, or this operation may be combined with advancement of the internal rectus. Usually advancement of the interni, one or both, according to circumstances, is preferable to tenotomy of the externi; but the latter operation may be needed to secure parallelism of the visual axes. A coexisting vertical deviation should be remedied, and some operators (Hansell and Reber) prefer to make the vertical adjustment before attacking the lateral deviation.

**Results of Tenotomy in Convergent Strabismus.**—The effect of the operation, if well performed, is to produce parallel visual axes, and thus remove the disfigurement. Properly speaking, a *cure* is obtained only when there is improvement in the vision of the squinting eye and binocular vision is secured. There is much difference of opinion on this subject, and some authors—for example, Lang and Barrett—doubt if valuable improvement in the vision of the amblyopic eye ever takes place. Noyes believed that binocular vision was secured in less than 20 per cent. of the cases, even after the most perfectly performed operations and after the patients' eyes had been carefully corrected with glasses and trained by orthoptic exercises. With patience and care, however, according to the methods already described, a greater success than the one just stated should be obtained. So, too, if the visual field is normal and scotomas are absent, improvement in the visual acuity of the squinting eye may be expected in a fair percentage of cases.

## Abnormal Balance of the Ocular Muscles 607

It always occurs, according to W. B. Johnson, if the seeing eye is removed or becomes blind.

It is often difficult to ascertain whether true binocular vision exists, especially in young children, and successful bar reading, usually quoted as a sufficient test, is, according to Priestley Smith, not without its fallacies. This author tests as follows:

A reversible frame carrying red and blue glasses is placed in front of the patient's spectacles, and he is shown, at the reading distance, a card with three discs on a black ground, a white one in the middle, a red one above, and a blue one below. If he can see all three at once and in a line, he is probably using both eyes and fusing the two images of the white disc. If with each eye alone he sees two, but with both eyes three, the proof is fairly positive. The test may be improved by placing a black letter on each disc, which, if the patient has sufficient vision, he should read. The same test with larger objects may be used at longer ranges. The light should be good, but not too strong, and not artificial. Hering's drop-test may also be employed.

Dr. J. A. Lippincott, of Pittsburg, has suggested that the binocular metamorphopsia produced by correcting lenses, and referred to on page 187, may be utilized for testing binocular vision, which is necessarily present if this phenomenon takes place. His method is as follows:

A + 2 cylinder, vertical, is held before one eye, while a 12-inch-square card is placed at the ordinary reading distance and the patient asked to describe which of the two sides is higher. As a control-test the cylinder is now turned with its axis horizontal and the card again viewed. That side which in the first place appeared higher, now seems to be lower than the other.

**Spastic Strabismus.**—This occurs only under rare circumstances in hysteria and brain diseases (meningitis). It is difficult of diagnosis, periodic concomitant squint in hyperopia being sometimes inaccurately described as due to spasm of the internal rectus (Mauthner).

**Abnormal Balance of the Ocular Muscles or Heterophoria** (*Latent Deviation*).—This is, as already defined, a dis-

## 608 Movements of the Eyeballs and their Anomalies

turbance of the normal balance of the external eye muscles, which creates a tendency for the visual lines to depart from parallelism, a tendency which is checked by the habitual desire for binocular vision, or that vision in which the images of an object formed on the retinas of the two eyes make but a single mental impression.

*Heterophoria* (*imbalance*, according to Gould) differs from *squint* or *heterotropia* because in the latter the fusion of the images is usually impossible—*i. e.*, binocular single vision is absent—and there is an evident departure of the visual lines from parallelism, which gives rise to the term which designates the condition.

**Causes.**—Imbalance of the ocular muscles may be due to: (a) weakness of the muscles (properly called insufficiency) of congenital origin, or depending upon a general lack in muscular tone, the result of anemia, nervous exhaustion, pelvic disorders, etc., or malaria, rheumatism, uric acid diathesis, etc., diseases which, however, may also be potent by affecting not the muscles themselves, but their innervation; (b) errors of refraction and disturbance of accommodative efforts (*accommodative heterophoria*); (c) the anatomic arrangement of the parts—for example, faulty attachment of the muscle (*concomitant heterophoria*); (d) excessive action or spasm of opposing and dominating muscles (*spasmodic heterophoria*); (e) disturbances of innervation (*central heterophoria*); and (f) a paretic condition of the muscle (*paretic heterophoria* of Duane).

**Varieties.**—According to Stevens's nomenclature, if there is a tending of the visual lines in parallelism, the term *orthophoria* is applied; if there is a tending of these lines in some other direction, the term *heterophoria*. Heterophoria is divided into: *esophoria*, a tending of the visual lines inward; *exophoria*, a tending of the visual lines outward; *hyperphoria* (right or left), a tending of the right or left visual line in a direction above its fellow. *Cyclophoria*, according to Savage, is a want of equilibrium on the part of the oblique muscles (see also page 77).

Abnormal inward tending of the visual lines may depend upon excessive convergence or deficient divergence, or upon

## Abnormal Balance of the Ocular Muscles 609

these conditions combined. Duane<sup>1</sup> describes the signs as follows: If *esophoria* for distance is less than for near, abduction (prism-divergence) not disproportionately low, adduction (prism-convergence) readily performed, esophoria marked at the near point and the convergence near point excessive, *convergence-excess* is present. If esophoria for distance is much greater than for near, abduction (prism-divergence) disproportionately low or absent, adduction (prism-convergence) normal or subnormal, esophoria slight, absent, or replaced by exophoria at the near point, and the convergence near point not abnormally close to the nose, *divergence-insufficiency* is present.

Convergence-excess is followed, if of long standing, by divergence-insufficiency, and similarly divergence-insufficiency by convergence-excess. In the *mixed form* thus produced there are marked esophoria for near and far, excessive approximation of the convergence near point, and limited, absent, or negative abduction (prism-divergence). Finally, the deviation ceases to be latent, binocular vision is lost, and *esophoria* passes into *esotropia*.

Abnormal outward tending of the visual lines may depend upon deficient convergence or excessive divergence, or upon these conditions combined. Duane records the symptoms as follows: If *exophoria* for distance is slight or absent, abduction (prism-divergence) not very great or even subnormal, adduction (prism-convergence) exceedingly difficult, exophoria marked at the near point, and the convergence near point less than three inches and maintained only for a moment, there is *convergence-insufficiency*. Sometimes this may be so great as to constitute a *convergence-paralysis*. If exophoria for distance is marked, abduction (prism-divergence) is high, adduction (prism-convergence) normal or not greatly subnormal, and the convergence near point normal, there is *divergence-excess*.

Convergence-insufficiency is followed, if of long standing,

<sup>1</sup> *American Text-book of Diseases of the Eye, Ear, Nose, and Throat*, edited by de Schweinitz and Randall, page 515. The descriptions which follow are condensed from Duane's article.

## 610 Movements of the Eyeballs and their Anomalies

by divergence-excess, and similarly divergence-excess by convergence-insufficiency. In the *mixed form* thus produced there are marked exophoria for near and far, excessive abduction (prism-divergence), and marked retreat of the convergence near point. Finally, the deviation ceases to be latent, binocular vision is abandoned, and *exophoria* passes into *exotropia*.

If hyperphoria, again to quote Duane, varies noticeably in different directions of the gaze, it is *non-comitant* and is due to underaction or overaction of one or more of the elevators or depressors; it may be due to spasmodic action of these muscles and may spontaneously disappear. If hyperphoria remains the same in all directions of the gaze, it is *comitant*, and may be due to excessive sursumvergence, or more frequently to the same agencies which produce non-comitant hyperphoria which has become comitant.

Whether the hyperphoria is due to overaction or underaction of one or other set of muscles may be determined by examining the rotations of the eyes (page 569). Excessive upward rotation would naturally indicate overaction of the elevators of the hyperphoric eye, and excessive downward rotation overaction of the depressors. Deficient upward or downward rotation would indicate underaction of the vertical muscles, and under these circumstances diplopia is readily elicited, as it is in parietic conditions, by carrying the test-light in the direction of the action of the affected muscle. Hyperphoria usually does not tend to increase, and therefore binocular fixation is usually retained, and it is comparatively rare for *hyperphoria* to pass into *hypertropia*.

Full correction of hyperopia disturbs the relative range of accommodation and convergence and may cause exophoria (convergence-insufficiency—relative insufficiency of the interni, according to Risley). The same condition is seen in myopes who do not use glasses at close ranges and in presbyopes whose reading-glasses are too strong. Suitable glasses, or a modification of the glasses, and sometimes exercises with prisms, will relieve the condition.

**Relative Frequency of Heterophoria.**—Faulty directing power of the vertical muscles (hyperphoria) is usually stated

to be the least common of these anomalies, but is much more frequent than was once supposed, and, according to Hansell and Reber, will be found in one-third of the cases of refractive anomalies. Many of these hyperphorias, however, are temporary in character and require no treatment except correction of the refraction and any underlying constitutional condition. The power of hyperphoria in causing asthenopic symptoms is of paramount importance, and, according to Stevens, its rôle in disturbing the action of the lateral muscles is significant.

Exophoria is usually stated to be the most common type of muscular imbalance, but Dr. Noyes considers esophoria more frequent than exophoria, the preponderance being 3 to 1, and this certainly is in accord with common experience. Heterophoria may be associated with any type of refractive error.

**Difference Between Heterophoria and Heterotropia (Squint).**—The essential difference between these two conditions has already been several times defined, and the passage of a heterophoria into a heterotropia has been described. The differential diagnosis should depend upon the results obtained from the application of certain tests. Duane describes these as follows:

"If there is any noticeable deflection behind the screen (page 78), the *screen-test is applied in a second way* or by *binocular uncovering*. This procedure consists in covering the left eye and then uncovering both eyes and noticing the movement that takes place. If, on thus uncovering the left eye, the right eye remains steady and the left moves into position, the patient has binocular fixation, and the deflection was a heterophoria and not a squint. If, however, the right eye should move out of its position and the left eye should move into place, there is a squint and the left is the fixing eye. If neither eye moves, there is a squint and the right is the fixing eye. By repeating this experiment with each eye alternately the examiner can tell whether there is a habitual binocular fixation, an alternating fixation, or a unioocular squint. The diagnosis between the three may be conveniently formulated as follows:



## 612 Movements of the Eyeballs and their Anomalies

" 1. If in binocular uncovering *but one eye moves*, heterophoria and not squint exists.

" 2. If either *both eyes move* or, in spite of there being an evident deviation, *both eyes remain steady*, squint exists.

" 3. In the latter case, if, when the left eye is uncovered, the eyes behave in the same way as they do when the right eye is uncovered (both alike moving or both alike remaining steady, no matter which eye is uncovered), the squint is *alternating*.

" 4. If, when one eye—for instance, the right—is uncovered, both eyes move, and when the other eye (in this case the left) is uncovered both eyes remain steady, the squint is *uniocular* (confined in this case to the left eye)."

**Symptoms.**—These are usually classified under the general term *muscular asthenopia*, and may be divided into the *ocular* and the *general* symptoms.

To the *first group* belong pain, often over the insertion of the insufficient muscle, and especially marked when the eye is suddenly moved in the direction of its action; blurred vision and imperfect power of working at close ranges; inability to gaze attentively at a stationary object or person even at long ranges, and great discomfort when attempting to watch moving objects; dread of light and blepharospasm, often confined to a few fibers of the orbicularis; and local congestions of the conjunctiva, especially over the affected muscle and on the margins of the lids. Often there are eccentric poses of the head and distortions of the features, especially wrinkling of the forehead.

In the *second group* the prominent symptom is *headache*, which may be situated in any portion of the cranium, but which is common in the occiput. The pain may immediately follow the use of the eye, or be delayed, or come on at a certain hour of the day, or even night. It may be a typical *migraine*. According to Gruening, morning headache—*i. e.*, headache on waking—is usually due to nasal catarrh.<sup>1</sup>

Pain in the back, especially between the shoulder-blades, or

<sup>1</sup> The association between nasal disease and neurasthenic asthenopia is referred to on page 466.

precordial pain, is common. Vertigo, generally subjective, is frequent, one variety being characterized by a sense of falling forward when walking in a crowd, associated with confusion of ideas. Drowsiness and, on the other hand, insomnia, may be present, and a variety of general or so-called reflex neuroses.

Chorea, epilepsy, pseudochorea, night-terrors, melancholia, neurasthenia, palpitation of the heart, indigestion, constipation, flatulent dyspepsia, and a host of other complaints have been attributed to muscular and also to accommodative asthenopia, and under these conditions the eyes should always be examined and the ocular defects corrected. Many instances of remarkable nervous disturbances are associated with heterophoria, especially hyperphoria (as well as with refractive error), and cure will often follow the relief of the ocular difficulty. Unfortunately, the whole matter has not always escaped exaggeration.

**Method of Examination.**—The method of examining the ocular muscles has been fully described in pages 78–86. Two points deserve reiteration—viz., that a measurement of the relative weakness and power of the muscles is inexact unless this has been made after the refractive error has been corrected, and the muscles have been tested through the correcting lenses; and that the examinations of the muscles should be made both for the *near* and the *far* point,—*i. e.*, at 30 cm. and 6 meters,—the latter being the more important determination.

**Treatment.**—As Duane has well said, “There must be no attempt to treat an insufficiency simply as an insufficiency, but account must be taken of the complex causes which lie at the root of it.”

Strict orthophoria is rare. Small errors of the lateral muscles are often unimportant.

If there is a constitutional disorder or an insufficient nervous tone, this must be treated on general principles. Strychnin or ascending doses of tincture of nux vomica are often efficient. Galvanism may be tried, but it is doubtful if the current reaches the muscle. Large doses of tincture of

## 614 Movements of the Eyeballs and their Anomalies

hyoscyamin are of distinct advantage in cases of spasmodic heterophoria.

In every case of heterophoria the refractive error should be corrected, according to the rules already laid down. In many instances this alone will suffice to restore the balance and cure the asthenopia. In esophoria of accommodative origin the total amount of the hyperopia and astigmatism should be neutralized with suitable glasses, which are to be worn constantly; in exophoria, especially with insufficiency of convergence, the full correction of the myopia should be ordered. When esophoria exists with myopia and exophoria with hyperopia, this plan must be modified, and an undercorrection of the refractive error prescribed. Convergence-insufficiency caused by glasses of improper strength has been described on page 610.

If the symptoms continue, recourse should be had to *gymnastic exercises with prisms*. The object is to strengthen abduction and adduction. A number of methods are in common use :

1. The patient is instructed to practise fusing the double images produced by viewing a candle-flame situated 6 meters away. Abduction (prism-divergence) and adduction (prism-convergence) are exercised, beginning with the weakest prisms and gradually increasing to the strongest. This plan probably acts, as Maddox suggests, by training the efforts of accommodation and convergence to assume broader relations to each other in their work. It is efficient in selected cases.

2. Rhythmic exercises, contraction and relaxation of the muscle being secured by causing the patient to view a small gas-jet 20 feet distant through *adverse prisms*,<sup>1</sup> which are lowered and raised at regular intervals of five seconds, beginning with weak and gradually going to stronger numbers. This is the method of Dr. G. C. Savage. This author also recommends rhythmic exercises by rotating convex cylinders before the eye for the relief of *cyclophoria*.

<sup>1</sup> "Adverse prisms" is a term used by Maddox, and means one with its apex set in the opposite direction from a "relieving prism"; for example, base out if the interni are to be affected, base in if the externi are to be exercised.

3. The patient is provided with prisms double the primary distant adduction-power. The candle-flame is then slowly carried, while he regards it fixedly and continuously from the near point to the distant point. This is repeated until, without difficulty, he can, through the prisms, secure a single image in all parts of the room. The strength of the "handicap-prisms" should be gradually increased. For esophoria the reverse of the plan is pursued. This is the method advocated by Dr. Gould.

Exercises with prisms, bases out, are followed by the most satisfactory results in exophoria, especially when this depends upon feeble adduction (convergence-insufficiency, according to Duane), and should always be practised. Exercises with prisms, bases in, in esophoria have not, in the author's experience, been of any value; nor have prismatic exercises given relief in hyperphoria. There is, however, much evidence to prove the usefulness of rhythmic exercises in esophoria and hyperphoria; they should be faithfully tried.

The next method of treatment is the *prescription of prisms*. The action of prisms has been explained (p. 19). Much difference of opinion exists in regard to their therapeutic value. The author believes with Duane that "the employment of prisms in lateral deviations is to be avoided, except as a temporary measure, since prisms, base in, tend to produce convergence-insufficiency, and prisms, base out, convergence-excess, so that in both cases they ultimately increase the deviation which they are designed to correct." Prisms may be ordered when the range of movement is perfect but in an unavailable position. There is one rule which admits of no exception in ordering prisms: The base of the prism should be placed toward the muscle which is to be aided, and the apex toward the muscle which is to be weakened.

It is usually uncomfortable for the patient to wear more than  $4^{\circ}$  or  $5^{\circ}$  constantly—*i. e.*, 2 or  $2\frac{1}{2}$  over each eye. This statement, however, admits of many modifications, and often the strength of the prism may be increased much beyond this limit.

In permanent latent deviations of the vertical muscles (right

## 616 Movements of the Eyeballs and their Anomalies

or left hyperphoria) the defect is often quite small, and usually not above  $4^\circ$  or  $5^\circ$ ; hence prisms may readily be ordered for continuous use, and combined with the lenses which correct the refractive error, forming a *prismosphere*. If, for example, there is right hyperphoria of  $2^\circ$ , a  $2^\circ$  prism base down before the right eye corrects the difficulty, or, what is equivalent, the prism may be divided between the two eyes—*i. e.*,  $1^\circ$  base down before the right, and  $1^\circ$  base up before the left. It is safe to correct very trifling errors in the vertical muscles either with prisms or by decentering the correcting lens to an equivalent degree (see page 21), providing these errors are still maintained after continuous use of glasses which neutralize the refractive error.

In esophoria, which is a frequent cause of muscular asthenopia (according to Noyes, the most frequent cause), prisms are often combined with the correcting lenses and worn constantly. Dr. Noyes's rule is as follows: If adduction stands at  $20^\circ$  or  $25^\circ$ , and after a few days rises still higher, while abduction remains at  $5^\circ$ , and distressing symptoms exist, the indication for prisms with bases out is clear enough for trial. If abduction be  $4^\circ$  or less (because half degrees are important), the indication is conclusive. There are many exceptions to this rule. For the reasons before stated the author doubts the value of constant prisms.

In exophoria the constant use of prisms is not advisable. On the other hand, they may be a great help in relieving the strain upon convergence by removing the point of intersection of the visual axes farther from the eyes, and for this purpose they are combined with reading-glasses. In high degrees of exophoria, or if there is actual divergence, abductive prisms are of little use; if the deficiency of the directing power is determined to be equivalent to  $10^\circ$ , one-half of this may be corrected—*i. e.*,  $2\frac{1}{2}^\circ$  base in over each eye; if it is desired to remove all effort, the faulty tendency is measured in the usual way, and if it is within suitable limits, prisms are ordered, combined with the correcting glasses which neutralize the defect.<sup>1</sup>

<sup>1</sup> When a spheric lens is combined with a prism, the deviating effect of the combination is different from that of the prism alone. Mr. Archibald Percival

It has also been suggested to strengthen the muscles by means of *orthoptic exercises*—*i. e.*, by causing them to make forced movement in different directions; by making forced movements of convergence, the patient being required to look at near objects—"thumb exercises"; by requiring the eyes to unite the images of two slightly separated objects. Stereoscopic exercises are also of advantage.

In the event of failure to relieve asthenopic symptoms by the methods thus far described operative procedure may be necessary. This consists of partial, complete, or graduated tenotomy of the antagonistic muscle, or of advancement of the feeble muscle (see chapter on Operation). Whether advancement or tenotomy should be performed depends upon the conditions. Advancement is indicated when it is desired to strengthen a weak muscle, and tenotomy when an over-strong muscle is to be weakened. For example, in exophoria due to convergence-insufficiency advancement of the internus is a more rational procedure than tenotomy of the externus, but if the exophoria depends upon divergence-excess, then tenotomy of the externus is the better operation. The same advice applies to esophoria, convergence-excess indicating tenotomy of the internus, and divergence-insufficiency advancement of the externus. According to circumstances, one or both externi or interni may need readjustment or division. Operations on the vertical muscles must be governed by similar rules. Surgical interference is required only when all other measures have been long and faithfully tried and have failed to give relief. While cases of muscular imbalance, best treated by operative interference, are encountered (aptly called by Risley "absolute insufficiencies," equivalent to the structural and insertional anomalies of Duane), in the opinion of the author they represent a limited proportion of the whole number. Moreover, as our knowledge of the etiology of abnormalities of muscular balance increases and our methods of non-surgical treatment improve, this number grows steadily smaller.

(*Ophthalmic Review*, October, 1891) has constructed elaborate tables which give the deviating effect.

## 618 Movements of the Eyeballs and their Anomalies

So-called graduated tenotomies and partial tenotomies are performed by some surgeons, and it is asserted that adjustments are exactly made, but in them the author has no faith. It is true that brilliant results have been made and described by experienced operators, but there is no doubt that a good deal of injudicious "snipping of the tendons of the ocular muscles" has been practised.

**Nystagmus.**—This term is applied to a condition characterized by an involuntary, rapid movement of the eyeballs. The movement may be lateral, vertical, rotary, or mixed—*i. e.*, a compound of two varieties.

The condition may be *congenital* or *acquired*, and is bilateral in the vast majority of cases, although a few instances of unilateral nystagmus have been reported, with the movements usually in the vertical direction. It is possible, however, inasmuch as slight forms of nystagmus are detected only by using the ophthalmoscope and watching the fundus, that some of these supposed unilateral cases have actually been bilateral.

The movement is nearly always in the lateral direction. According to Gowers, the extent varies from 1 to 10 mm., and the frequency from 60 to 200 separate oscillations a minute.

Congenital nystagmus is seen with cases of defective construction of the eyeball—coloboma, microphthalmos, etc. It is also common in albinism. Nystagmus also occurs with opacities of the media, especially when such obstruction to the rays of light has been caused by diseases occurring early in life and in blind eyes.

Nystagmus may be acquired by the pursuance of certain occupations, especially mining, and is commonly known as *miner's nystagmus*. It generally occurs among those who use a dim light, and whose work necessitates keeping the eyes in an unusual position for many hours together (Snell).

Finally, nystagmus is exceedingly common in diseases of the nervous system, particularly disseminated sclerosis and Friedreich's ataxia. It occurs in many diseases of the brain, and has been noted with great frequency in tumors of the cerebellum.

Nystagmus has been ascribed to chronic fatigue of the mus-

cles and oscillation of the globe consequent upon the muscular atony, and also to a central origin. In some cases it is probable that both explanations are correct.

**Treatment.**—If practicable, in cases of nystagmus where there is interference with the reception of perfect retinal images, the best possible vision should be restored by correction of refractive error, by tenotomy, or by iridectomy for new pupil, according to the indications. Very often good results have been noted. If nystagmus is brought about by any occupation, the evident indication is to remove the patient from his surroundings. For central nystagmus from brain or cord disease there is practically no remedy. In some instances of acquired nystagmus benefit has been reported from the local use of eserine and the internal administration of strychnine.

**Monocular Diplopia.**—This character of diplopia has been explained by one of several conditions: (1) By anomalies of refraction, particularly astigmatism; (2) by opacities in the cornea or lens (see also page 432); (3) by irregular cramp of the ciliary muscle; (4) by complete or partial constriction of the eyelids, by which they are made to impinge on the cornea (G. J. Bull); (5) by hysteria or allied functional nervous disturbance; (6) by organic disease of the brain or its membranes, associated with abducens paralysis (Gunn and Anderson); (7) by simulation, the symptom being an invention of the patient for the purpose of magnifying the result of injuries.



## CHAPTER XX.

### DISEASES OF THE LACRIMAL APPARATUS.

DISEASES of the lacrimal structures naturally divide themselves into those which have their seat in the lacrimal glands and those which affect the drainage system—*i. e.*, the puncta, canaliculi, lacrimal sac, and nasal duct.

**Dacryo-adenitis.**—This is an inflammation of the lacrimal gland, a comparatively rare affection, which may be *acute* or *chronic*, *suppurative* or *non-suppurative*.

Non-suppurative dacryo-adenitis, on account of its analogy to bilateral parotitis, has been called *mumps of the lacrimal gland* (Hirschberg). It may be caused by influenza, small-pox, leukocythemia, and mumps. Tubercular dacryo-adenitis is rare according to Stieren, who reports an example of this affection, only 12 cases being on record. The monolateral chronic form of inflammation of the lacrimal gland is more common, and has been observed in scrofulous subjects, and may be caused by an injury or follow diseases of the conjunctiva and cornea.

If the gland is chronically enlarged, palpation will reveal its lobulated border; if the inflammation is acute, there are pain, tenderness, and swelling at the upper and outer part of the eyelid, with chemosis of the conjunctiva. This may go on to suppuration, and the abscess usually points upon the skin, but occasionally through the conjunctiva.

**Treatment.**—Warm applications and poultices to relieve pain are needed, and at the first appearance of pus an incision should be made either through the integument parallel to the eyebrow, or through the conjunctiva. If induration of the gland occurs, this is to be treated locally with iodine or iodide of cadmium ointment.

**Hypertrophy of the lacrimal gland** has been observed at birth, but usually is seen in later years, and consists in an

indurated lobulated tumor having its situation in the upper and outer part of the orbit.

**Atrophy of the lacrimal gland**, as the result of xerophthalmos, has been described.

**Spontaneous prolapse of the lacrimal gland** appears in the form of a soft movable tumor under the upper eyelid, and has been several times reported. Hypertrophy and prolapse or prominence of the palpebral portion of the lacrimal gland may occur in various corneal and conjunctival inflammations, and is evident on everting the upper lid.

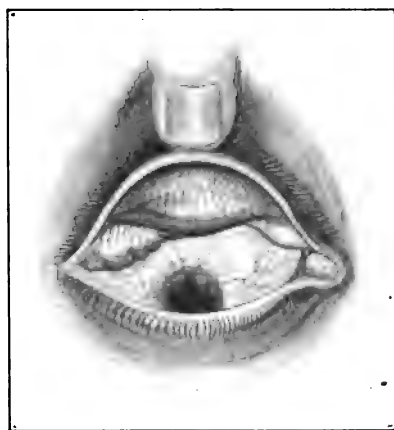


FIG. 185.—Enlargement and prolapse of the palpebral portion of the lacrimal gland in an eye with kerato-iritis.

The **treatment** consists of extirpation of the prolapsed organ.

**Fistula of the Lacrimal Gland.**—This may remain on account of the rupture of an abscess, but has also been recorded as a congenital defect. When it is the latter, the orifice has been seen at the outer third of the upper lid, and in one case was surrounded by a tuft of hair.

The fistula may be closed by repeated cauterization or by a plastic operation; in the event of the failure of these measures, extirpation of the gland is indicated.

**Syphilis of the Lacrimal Gland.**—The lacrimal gland is singularly free from syphilitic affections, but specific indura-

tion and inflammation have been described, and in any instance of unaccounted hypertrophy of this gland, careful antisyphilitic treatment should be undertaken before resorting to surgical measures.

**Dacryops.**—This affection, often classified with diseases of the conjunctiva, is caused by a cystic distention of one of the gland-ducts, and appears in the form of a bluish, translucent swelling beneath the conjunctiva at its upper and outer part. If the mouth of the excretory duct is not occluded, pressure upon the tumor causes a few drops of liquid to escape.

**Treatment.**—Incision of the walls of the cyst causes it to collapse. The wound should be opened from time to time in order to prevent too rapid cicatrization.

**Tumors of the Lacrimal Gland.**—Adenoma, fibroma, myxoma, adeno-angioma, epithelioma, carcinoma, osteochondroma, lymphoma, cylindroma, and sarcoma occur. Tubercle has also been reported in this region. Cysts and concretions (dacryoliths) occur. According to Warthin, the majority of lacrimal tumors are most probably mixed tumors of endothelial origin, similar to those of the parotid and submaxillary glands. They tend to form cartilaginous, hyaline, and myxomatous tissue, and their malignancy is relatively slight.

Excision of the growth is the proper remedy.

**Anomalies of the Puncta Lachrymalia and Canaliculi.**—1. **Congenital Anomalies.**—Double puncta lachrymalia and canaliculi have been observed as congenital anomalies. There may be congenital absence of these structures, or the lacrimal points may be wanting and the canals may be represented by furrows along the edge of the lid.

2. **Acquired Anomalies.**—The slightest change in the natural relation of the lower punctum to the eye, against which it is directed backward, causes *epiphora*, or an overflow of tears.

The most fruitful sources of such abnormal relationship are the various chronic inflammations of the lid and conjunctiva—blepharitis, granular conjunctivitis, and ectropion—and facial palsy and wounds of this region. In facial palsy, watering of the eye is sometimes an early symptom, and is caused partly by the loss of the compressing power of the lid, especially in

## Anomalies of the Lacrimal Sac and Nasal Duct 623

the fibers of Horner's muscle, and partly by the falling away of the punctum. An overflow of tears may follow an abnormal position or enlargement of the caruncle. All these conditions, then, cause a *malposition* of the *punctum lachrymale*.

Epiphora is also caused by a styte or tumor of the lid near the punctum, or, if the canaliculus is closed, by the presence of a foreign body, usually a cilium; by a mass of fungus (*leptothrix*) which, by becoming calcified, may form a so-called *tear-stone*, or even by a *polyp*. In like manner chronic conjunctivitis and marginal blepharitis may close either the lacrimal point or the canaliculus. These affections, then, are included under the terms *stenosis* of the *punctum lachrymale* and *obstruction* of the *canaliculus*.

**Treatment.**—In cases of epiphora without disease of the lacrimal sac or stricture of the nasal duct a simple slitting of the canaliculus is usually sufficient. If a foreign body is present, this should be removed.

In some cases of epiphora which seem to depend simply upon closure of the lacrimal point this may be opened by means of a gold or silver pin or a *dilator*, which is pushed along the canaliculus. Afterward the permeability of the lacrimal duct may be tested by inserting the point of an Anel syringe and injecting boric acid solution and observing whether it passes freely into the nose. This very simple procedure will often afford great relief without the necessity of either slitting the canaliculus or dilating the duct. If the epiphora has been caused by facial palsy, the treatment advised does not apply.

### **Anomalies of the Lacrimal Sac and Nasal Duct.**—

1. **Dacryocystitis.**—The symptom in affections of the lacrimal sac and nasal duct which is always present is epiphora; the eye swims in tears, and these are excited to overflow by exposure to dust, cold, or wind; the caruncle and plica are swollen; the neighboring conjunctiva is hyperemic and injected (*lacrimal conjunctivitis*); the skin is macerated, and the margins of the lid, especially toward the nose, show signs of blepharitis.

Usually there is slight distention over the region of the lacrimal sac (*mucocoele*, *lacrimal tumor*), and pressure upon this expresses through the puncta the retained fluid, which is a clear or semitransparent viscid mucus (*dacryocystitis catarrhalis*), or turbid from mixture with purulent material (*dacryocystitis blennorrhoeica*).

This *chronic* distention of the lacrimal sac is liable to develop into a suppurative inflammation producing *acute dacryocystitis*, which may be preceded by fever and chill; the lids and region of the nose become tense and tender to the touch, and a red and brawny swelling resembling erysipelas, for which it not infrequently has been mistaken, overspreads the region.

When there is added to disease of the sac a phlegmonous



FIG. 186.—Phlegmonous dacryocystitis; pouting granulations surround the fistulous orifice (from a patient in the Children's Hospital).

inflammation of the cellular tissue (*dacryocystitis phlegmonosa*) which surrounds it, the pus burrows in front of the sac, forms pouches in the connective tissue, and in most instances the *lacrimal abscess* thus formed points below the *tendo oculi*. If unmolested, the abscess ruptures externally with the formation of a fistulous opening into the sac, the mouth of which is surrounded by pouting granulations (Fig. 186).

**2. Prelacrimal Sac Abscess.**—This consists of a swelling above the internal palpebral ligament and a little external to the region of the lacrimal sac, associated with a fistulous opening, from which pus flows, having no connection with the sac itself. It may be caused by a blow at the inner angle of the eye and

may be associated with caries and perforation of the lacrimal bone (Bull). The same condition appears without injury in children who are the subjects of hereditary syphilis.

The condition is to be distinguished from a true lacrimal abscess by the fact that there is no interference with the passage of tears from the conjunctiva into the sac, and by the absence of acute inflammation. Prelacrimal sac cysts are described, and small tumors may appear in this region. One removed and examined by the author had all the histologic appearances of tubercle.

The *treatment* is that of an abscess, together with such constitutional measures as may be indicated by the dyscrasia of which the patient is the subject.

**3. Fistula of the Lacrimal Sac.**—This occasionally has been observed as a congenital anomaly, and may be present on only one side or on both sides. The opening is usually directly under the internal palpebral ligament.

Generally a fistulous opening into the sac is caused by the *rupture of a lacrimal abscess*, but it may result from a carious condition of the upper canine teeth. The opening may appear about one centimeter below the punctum, but also in various spots along a line which runs outward, parallel to the lower orbital border.

It usually communicates with the sac, but in rare instances the opening may lead into the lower canal only, the sac above being shrunken. Pus and mucopus, and later tears, which should descend into the duct, exude from the opening, which for a long time persists as a fine orifice, at the mouth of which appears a drop of clear fluid. This is the so-called *capillary fistula*.

The condition is to be differentiated from a *buccal fistula* below the margin of the orbit, by observing that in the latter the situation is never accurately at the orbital margin, that a sound never passes upward but only downward, laterally, or posteriorly, and that the secretion is always purulent.

**4. Obstruction of the Nasal Duct.**—This generally antedates the affection of the sac. It may be situated at any part, but selects by preference the point at which the nasal duct enters

## 626 Diseases of the Lacrimal Apparatus

into the sac, or the lower end where it passes into the nasal chamber.

In the early stages of catarrhal dacryocystitis there probably is no true stricture of the duct, but the flow from the sac into the nose is prevented by swelling of the mucous tissue; later, and in other instances, dense cicatricial strictures occur.

### **Cause of Disease of the Lacrimal Sac and Nasal Duct.—**

Disease of the lacrimal sac is rarely primary. In young infants dacryocystitis, often double, is not infrequently seen—*lacrimal blennorrhoea of infants*. Donald Gunn thinks that the cause of mucocele found at birth of children, becoming afterward dacryocystitis, depends upon a dilated duct, the dilatation being brought about during fetal life by obstruction at the lower end, depending, for example, upon some developmental fault. Rochon-Duvignaud has shown microscopically that there may be an occasional congenital obstruction at the lower end of the nasal duct.

Both a local and a general disposition to tear-duct troubles has been assumed by some authors, and by others, for example, Haab, hereditary predisposition has been given etiologic prominence. The female sex suffers more frequently than the male, and the left tear-duct is more often diseased than the right (Cahn).

In the majority of cases blennorrhoea of the sac is caused by a retention of the secretion from stricture or obstruction in the nasal duct, and the participation of the lining of the sac in an inflammation of the nasopharynx. In other instances strictures result from, rather than cause, the blennorrhoea. A proper appreciation of the pathologic conditions of the nasal mucous membrane in relation to diseases of the lacrimal apparatus is of the utmost importance, and in nearly every case of disease of the lacrimal sac and of the lacrimonasal duct morbid conditions of the nasal chambers and of the nasopharynx are present, especially tumefaction of the mucous membrane, hypertrophy, and abnormal position of the turbinate bones, strictures after nasal ulcers, and caries of the nasal bones.

Although it might seem natural that conjunctivitis, and

## Lacrimal Secretion under Pathologic Conditions 627

especially purulent conjunctivitis, should cause lacrimal disease, this is by no means frequently the case. Conjunctivitis and blepharitis, so often accompanying disorders, follow, rather than cause, the lacrimal affection.

Obstruction of the duct and disease of the sac are sequels of measles, scarlet fever, and especially small-pox, because these exanthems are accompanied by inflammation of the nasal mucous membrane.

Periostitis and caries of the lacrimal bone, the result of syphilis, are important causes. Gummy growths may block the sac and go on to rapid suppuration.

The relation between asymmetry of the face and disease of the lacrimonasal duct deserves mention; indeed, Hasner assumed that a local disposition to these disorders depended upon this asymmetry. Traumatism accounts for certain cases. Most impermeable obstructions follow injuries and the rough use of bougies. Stoppage of the lacrimonasal duct may be caused by pressure from neighboring tumors—for example, in the antrum of Highmore, and by foreign bodies lodged in the lower lacrimal canal and in the nasal chambers. *Actinomycosis* of this region has been reported (von Schroeder).

*Fistulas*, especially those seen in infants, often arise from disease of the bone, which in turn is the result of inherited syphilis.

**Prognosis in Lacrimal Disease.**—The well-known fact that under the most skilful treatment affections of the tear-passages often resist healing, renders a guarded prognosis necessary. This depends entirely upon the condition of the nasal chambers, the duration of the malady, the permeability of the stricture, and the cause of the trouble. When the latter is the result of injury, the prognosis becomes especially grave, and the malady may be irremediable.

**Character of the Lacrimal Secretion under Pathologic Conditions.**—The lacrimal sac is a reservoir for the fluid secreted by the conjunctiva, and this fluid is more or less loaded with micro-organisms. The streptococcus pyogenes, pneumococcus, and other pathogenic organisms are always present in dacryocystitis. If the cornea is abraded, or



if a solution of continuity in this membrane is necessitated by an operation, the presence of these organisms in the fluid becomes a serious complication. They may turn a simple abrasion into a sloughing ulcer or an aggravated hypopyon-keratitis. They may prevent the healing of an ordinary keratitis, and finally they may inoculate an operative wound and defeat the object of the operation. For this reason it is most important that in any of the three conditions just quoted the permeability of the nasal duct should be ascertained. If it is strictured, it should be opened, and the walls of the lacrimal sac, if inflamed, brought to a healthy condition as speedily as possible, or the sac should be extirpated. The importance of this relation of the lacrimal apparatus to diseases of the cornea and to the prognosis of cataract operations has been elsewhere described.

**Treatment of Diseases of the Lacrimal Sac and Duct.**—

Conservative measures should always be tried first—viz., intranasal treatment, massage over the sac while the inner canthus is kept filled with an antiseptic liquid, and dilatation of the punctum and irrigation of the sac. Many cases of simple epiphora are due to ametropia and heterophoria and even to various nervous diseases,—for example, *tabes dorsalis* and *neurasthenia*,—hence operative interference is to be deprecated unless the exact cause of the condition is ascertained.

In organic cases usually three procedures are necessary—slitting the canaliculus, introducing the probe into the nasal duct, and syringing the sac and nasolacrimal duct. The method of slitting the canaliculus and the introduction of a probe are described on page 732.

After the canaliculus has been incised, the duct and the sac should be washed out thoroughly with some antiseptic fluid—a saturated solution of boric acid or a 1 : 5000 solution of bichlorid of mercury, or formaldehyd 1 : 3000, or permanganate of potassium 1 : 5000, or protargol, 5 to 10 per cent. Argonin, 2 to 4 per cent., has been recommended.

Some surgeons, as a rule, split the upper canaliculus, although the usual practice is to approach by means of the lower passage. If there is much distention of the sac, it has

## Treatment of Diseases of Lacrimal Sac and Duct 629

been suggested to enter the upper passage and incise both this and the wall of the sac.

In making use of probes, it is advisable to begin the first trial with a No. 1 conical probe (Bowman's or Williams'); if this fails, a smaller one may be tried. Either rapid or gradual dilatation is employed, the latter being the preferable method. Undue efforts should never be used, as it is extremely easy to make a false passage and perforate the delicate structure of the lacrimal bone, while roughness in the use of probes, by scraping off the mucous membrane, may cause the most impermeable type of stricture. For this reason, in some cases it has been suggested not to use probes at all, but simply by means of a syringe introduced into the mouth of the sac to medicate the inflamed tissue, which, as before stated, sometimes causes occlusion by swelling, without the actual presence of a cicatricial stricture.

Sounds should be used at first every second or third day, but as the case progresses longer intervals may elapse. Large probes (4 mm. in diameter) are advocated by Theobald and Snell.

If a lacrimal abscess supervenes and is seen early, the canaliculus should at once be slit and, if possible, the secretion evacuated with retention of the passage into the nose. Frequently the pain and swelling are such as to render this impossible, and the opening must be made upon the face, about 1 cm. below the palpebral tendon, cutting downward and outward. The cavity should then be thoroughly cureted, packed with gauze, and allowed to heal gradually from the bottom.

An excellent practice is to use hot compresses over the swelling, preferably of carbolized water, at a temperature of 120° F., frequently changed and applied for five or ten minutes at a time. Later the passage into the nose may be rendered patulous with probes, in the manner already described. The practice of introducing a lead or silver style the author has abandoned. The passage of bougies of gelatin impregnated with 30 to 50 per cent. of protargol has been recommended (Antonelli).

Swelling over and around the lacrimal sac, together with fistulous communication into it, occasionally will subside under the judicious use of a compressing bandage.

The great difficulty that is sometimes experienced in keeping the canaliculus open has led to the employment of *electrolysis*. This is applied to the canaliculus by means of a probe fitted in a handle and connected with the negative pole of a battery, the positive electrode being placed on the back of the neck. The *séance* should last about half a minute with a current of 2 milliampères.

In addition to the local measures already mentioned for the purpose of producing healing in cases of lacrimal disease associated with a catarrhal condition of the passages, solutions of nitrate of silver, salicylic acid, iodoform, aristol, creolin (1 per cent.), and blue pyoktanin (1 : 1000) have been advocated.

In acute inflammation with abscess formation, quinin, and iron in the form of Basham's mixture, are indicated; in syphilis, with disease of the bone and gummy deposit, the usual drugs should be exhibited; in struma, cod-liver oil, hypophosphites, and iron, in the form of the syrup of the iodid, are the most trustworthy remedies.

Scrupulous attention to the nose and the nasopharynx is necessary, and any local lesions which present themselves must be treated. In the absence of a special line of practice for this region excellent results follow a simple spraying of the parts with Dobell's solution or peroxid of hydrogen, one-third, water, two-thirds, while carrying on the regulation measures for the relief of the lacrimal disorder. If there is decided disease of the region, the proper treatment of the part with the view to removing diseased structures should be undertaken.

Occasionally it will happen that although a duct has been thoroughly opened, the probe passes readily and the liquid used in the syringe flows freely from the nose, the epiphora continues, and the eye fairly swims in tears. Under such circumstances a probe should be passed into the nose and the entrance of the duct into the inferior meatus properly exposed

## Treatment of Diseases of Lacrimal Sac and Duct 631

by means of a nasal speculum. Quite often it will be seen that a thickening of the duct-entrance, or perhaps a valve-like flap of mucous membrane, occludes the passage. This is pushed aside by the probe or forced aside by the liquid when it is injected, but entirely stops the flow of the tears. This simple precaution will sometimes lead to the discovery of the cause of failure to relieve cases which have stubbornly resisted treatment.

If a fistula remains, this may sometimes be healed, as already stated, by compression. In the event of failure, freshening of the edges and the galvanocautery may be tried, the surrounding pouting granulations being removed by scraping. The capillary fistulas are productive of no inconvenience and may be allowed to remain undisturbed.

*Extirpation of the lacrimal sac* is indicated, and usually yields good results in many cases of chronic dacryocystitis. It may be employed when conservative and ordinary surgical measures have failed, when the patient cannot or will not devote sufficient time to treatment, when there is an impassable stricture, when an operation on the eyeball is speedily necessary, when there is a serpiginous ulcer of the cornea (Kuhnt), and in cases of caries of the lacrimal bone. If, subsequently, the epiphora is annoying, *extirpation of the lacrimal gland* has been performed and is especially advocated by C. R. Holmes. In place of complete excision, removal of the palpebral gland may be tried (for methods of operating see page 735).

## CHAPTER XXI.

### DISEASES OF THE ORBIT.

**Congenital Anomalies.**—*Anophthalmos*, or complete absence of one or both eyes, is an affection which, like the other congenital anomalies, is more frequently observed to be double than one-sided. A child born without eyes may be healthy and well developed in other respects, or may be the subject of additional congenital deformities. The palpebral fissures are small, the lids usually deficient in size, sunken, and upon their separation the empty orbit without trace of the globe is revealed. Sometimes, however, careful dissection will reveal a rudimentary eyeball at the apex of the orbit.

The most reasonable explanation of this anomaly is that no primary optic vesicle has budded out from the anterior primary encephalic vesicle, or that, having budded out, it has failed to form a secondary optic vesicle.

*Microphthalmos* and *megalophthalmos* are anomalies of the globe to which reference has been made. Sometimes *cysts* of bluish hue are connected with rudimentary eyes, the cyst being evident in the lower part of the orbit or the lower lid—*orbito-palpebral cyst*.

*Cyclopia* is a congenital malformation characterized by a fusion of the orbits and the two eyes in the middle of the face, so that there is only one eye situated in the place normally occupied by the root of the nose.

**General Symptoms of Orbital Disease.**—Two symptoms are so constantly present that they may be said to be essential to the clinical picture of most of the affections of the orbit:

1. *Proptosis or Exophthalmos.*—This consists of more or less protrusion and displacement of the globe.

2. *Immobility of the Eyeball.*—This may be complete or partial, and, if vision is unaffected, the limitation of the movements of the eye is associated with diplopia. Complete im-

mobility may be differentiated from a similar condition due to palsy of all external ocular muscles (ophthalmoplegia externa) by the absence of ptosis (Noyes).

Less universally present, the following signs may be associated with orbital disease :

(a) *Chemosis of the conjunctiva*, either universal or else localized upon a special portion of the globe, indicating the neighborhood of the diseased area.

(b) *Redness, swelling, and edema* of the eyelids, especially in the inflammatory affection of the cellular tissue of the orbit.

(c) *Pain*, most noticeable when the patient attempts to move the eye, or when the surgeon palpates the globe and presses it inward. In addition to the pain in the orbit itself, *frontal headache* is a common symptom, especially when the frontal sinus is involved, and *tenderness on pressure* along the margin of the orbit and accessible portions of its walls is one sign of disease of the periosteum.

(d) *Fluctuation* occurs, but not constantly, when an abscess of the orbit has formed.

(e) *Disturbance of Vision*.—In some cases of orbital diseases there is no disturbance of vision; in others there may be marked changes in the eye-ground—papillitis, atrophy, hemorrhages, and vasculitis.

**Periostitis.**—Periostitis of the orbit is both *acute* and *chronic*, and in the acute type appears either as a *localized* affection or as a *diffuse* suppurative process.

The **symptoms** of acute localized periostitis are pain, tenderness over the seat of the disease, usually the margin of the orbit, injection and chemosis of the conjunctiva, and some swelling of the lids and protrusion of the ball. In the diffuse variety of the disease all the foregoing symptoms are much aggravated, and there may be, in addition, fever, general headache, delirium, and stupor. In such a case the differential diagnosis between it and an orbital cellulitis becomes extremely difficult. In fact, the cellular tissue is associated with the periosteum in the inflammation.

In chronic periostitis there are deep-seated pain, often worse

at night, tenderness on pressing the eyeball backward, thickening of the tissue beneath the orbital margin, and swelling of the lids and conjunctiva, although the latter symptoms, together with proptosis, may be absent.

According to Mracek, syphilitic periostitis most frequently attacks the orbital margins, and may occur in a *gummatous* or a *sclerosing* form. It less commonly involves the orbital walls behind Tenon's capsule, and is then generally gummatous in type. The site is usually in the upper or outer wall, and the disease causes trigeminal neuralgia, worse at night, and restriction in the mobility of the globe, with squint and diplopia. Optic neuritis may occur.

**Causes.**—The causes of periostitis, especially of the chronic form, in addition to syphilis, in which disease it is sometimes a secondary, but more often a late, manifestation, are rheumatism, scrofula, and injuries.

The **prognosis** depends upon the type of the disease. If localized, this is favorable; if diffuse and suppurative, not only may extensive implication of the tissues surrounding the globe leave permanent disabilities and deformities (exophthalmos, muscle palsy, optic-nerve atrophy, necrosis), but the inflammation may extend to the meninges of the brain and cause death.

Chronic periostitis may last for months, and in any type fistulas, necrosis, and caries of the bone are the common result. Periostitis due to syphilis presents the most favorable prognosis.

**Treatment.**—The constitutional treatment depends upon the cause, and includes the iodids and salicylates in rheumatic cases, and the free use of mercurials and iodid of potassium in syphilitic cases. Scrofulous patients should be given suitable remedies.

The surgical treatment of acute periostitis consists in an incision into the affected area and evacuation of the pus; in short, the treatment is the same as that applied to acute periosteal disease elsewhere located.

**Caries and Necrosis.**—Caries is prone to attack the margin of the orbit, especially the lower and outer part, and

may be due to syphilis or scrofula. An injury often is the exciting cause in scrofulous cases.

The **symptoms** of periostitis are present, suppuration develops, the abscess comes to the surface through the lid over the diseased area, rupture occurs, with the discharge of pus, a fistula forms, surrounded by granulations, and through this a probe will detect the softened bone. Very decided deformity of the lid may be occasioned, most commonly in the form of an ectropion (compare Figs. 82 and 85).

Caries of the orbit is most common in children, and, as has been pointed out, selects the margin of the orbit for its site, although it may occur in the roof, in which case it becomes a complication endangering life, owing to the proximity of the brain. The inflammation may spread to the orbital tissues and cause exophthalmos and neuroretinitis.

Necrosis of the orbit is much less common, and its immediate cause is an osteitis occurring as a consequence of acute periostitis. A fragment of bone completely separated by a fracture from the periosteal surroundings would probably undergo necrosis, and the rough use of probes may cause mortification of the delicate lacrimal bone. Necrosis, unlike caries, is more common in adults.

**Treatment.**—This consists of the remedies recommended in the treatment of periostitis, and, as caries is a very chronic affection and most common in strumous subjects, cod-liver oil, phosphates, and iodid of iron should be included in the constitutional measures, and should be exhibited for long periods of time.

The local treatment during the early ulcerative stage of caries consists of evacuation of foci of suppuration, careful cleansing with antiseptic solutions, and drainage. Considerable caution is necessary before resorting to the removal of the diseased bone with a gouge, because the process is essentially chronic and may be aggravated by the manipulations of the instrument; but roughened bone should be scraped with a sharp spoon and the diseased portions thoroughly removed. If the roof of the orbit is affected, great care is necessary lest the cranial cavity be penetrated. If a piece of



the orbital wall has undergone necrosis, this should be removed when it has become loose or detached.

**Cellulitis** (*Phlegmon of the Orbit*).—Under this term are included several varieties of inflammations of the cellulofatty tissue of the orbit. Thus the inflammation may be acute, subacute, or chronic, monolateral or bilateral, and finally it may undergo resolution, or, as more commonly is the case, terminate in suppuration.

In the *mild* form, the *symptoms* are dull pain, swelling of the lids, slight exophthalmos and diplopia, without inflammatory symptoms and without constitutional disturbance.

In the *acute* phlegmonous variety of the disease there are chills, fever, deep-seated pain, most marked upon attempting to move the eyes, general headache, exophthalmos, limitation in the movements of the eye (which may become entirely fixed), and swelling and edema of the lids, together with hyperemia and chemosis of the conjunctiva. The last two symptoms are so severe at times as to give at first sight the general impression of a violent attack of purulent conjunctivitis (Fig. 187).

In the earlier stages vision is not usually affected, but later there may be optic neuritis followed by atrophy, dilatation of the pupil, anesthesia, and even ulceration of the cornea, and, indeed, in bad cases the eyeball may pass into suppuration. In certain types of orbital cellulitis, extensive intra-ocular changes occur, with hemorrhages and vascular alterations, due to compression of the central vessels of the retina producing stoppage of the circulation and edema and exudation into the retina (Knapp). Fluctuation finally develops, and pointing usually occurs below the inner portion of the supra-orbital ridge.

The symptoms of *chronic* abscess are much less violent and distinctive than those just described. They may, indeed, be mistaken for other morbid conditions, especially as the abscess is commonly associated with diseased bone or periosteum in scrofulous subjects, or may occur in them from an injury or the presence of a foreign body.

**Causes.**—The causes of orbital cellulitis are various. It may be traumatic or idiopathic in origin and may be due to

exposure to cold; it may follow in the wake of scarlatina, typhoid fever, or influenza; or it may be the result of a meningitis. The most violent types of orbital cellulitis occur with facial erysipelas. In these instances the affection is usually double. The extension of inflammation from diseased teeth or suppuration in the ethmoid cells has been known to cause the affection. Finally, a certain number of cases are metastatic, and develop in the course of pyemia, especially puerperal septicemia. The association of orbital cellulitis with periostitis has already been referred to, and a certain amount of cellulitis occurs whenever there is a general inflammation of the globe.

#### Progress and Prognosis.—

In mild cases the prognosis is favorable; in severe cases, very unfavorable; and in double cases, especially those which have originated under the influence of erysipelas, usually fatal. Although the pus may make its exit through the conjunctiva, it

may also pass backward through the sphenoid fissure. In pyemic cases, and indeed in the course of any severe inflammation of the cellulofatty tissue of the orbit, *phlebitis of the orbital veins* may become a complication and extend to the cavernous sinus, leading to a fatal termination. If the disease passes to the cavernous sinus upon the opposite side, the other eye also becomes involved and exophthalmos is evident.

In making up a prognosis it is necessary to consider the effect of the disease upon the eye-sight and upon the life of the patient. Sight may be impaired or destroyed by the development of neuritis, atrophy, and exudation and hemorrhages into the retina, or by suppuration of the cornea; life may be en-



FIG. 187.—From a photograph of a patient in the Philadelphia Hospital suffering from double orbital cellulitis the result of erysipelas.

dangered by an extension of the suppurative process into the cranial cavity, or by the original malady which caused the cellulitis.

**Treatment.**—The general treatment should include supporting measures and iron and quinin. Locally, frequently changed hot compresses are proper, and in the early inflammatory stages, bleeding from the temple. As soon as there is the slightest suspicion of pus, incisions should be made, multiple if necessary, and preferably from the conjunctiva. Proper drainage having been secured, the discharging passage should be frequently syringed with an antiseptic solution.

It is not necessary to wait for an actual pointing before making use of a knife to evacuate pus, lest the delay cause serious complications from the compression of the tissues within the orbit. If the abscess has manifested itself by pointing, the incision is made with the knife introduced flatwise at the point of greatest fluctuation. A sinus may persist after the evacuation of an orbital abscess, especially one of the chronic type. This may be stimulated to heal by the use of astringent and antiseptic injections.

**Inflammation of the Oculo-orbital Fascia (*Tenonitis*).**

—This affection is characterized by swelling of the upper lid, pain on the slightest movement of the eye, some proptosis and limitation of movement, together with the appearance of a watery nodule or vesicle situated over one of the recti muscles; in other cases the chemosis may be more general. The affection may be idiopathic, or may follow an injury or an operation—for instance, tenotomy; in some instances it is due to rheumatism, and it has been noted as a sequel of diphtheria, typhoid fever, and epidemic influenza.

The treatment should consist of warm fomentations and, according to the indications, iodid of potassium or the salicylates.

**Thrombosis of the Cavernous Sinus.**—During phlegmonous inflammation of the orbit there may be thrombosis of the orbital veins, and extension from them to the cavernous sinus or to the other sinuses of the brain. Primary traumatic

non-infective thrombosis of the cavernous sinus has been described by Knapp.

Thrombosis of the cavernous sinus itself, however, as the result of some intracranial lesion, produces symptoms which are very like those of cellulitis of the orbit. This disease belongs more truly to the domain of neurology, but is extremely interesting on account of the ocular symptoms which accompany it—proptosis, edema of the eyelids and chemosis of the conjunctiva, haziness, anesthesia of the cornea, and partial or complete ophthalmoplegia—that is, gradual involvement of the third, fourth, and sixth nerves, venous engorgement of the retinal veins, and neuroretinitis.

**Tumors of the Orbit.**—These have been divided by systematic writers into those which originate in the orbit, but are unconnected with the globe of the eye; those which arise from the periosteum or bony walls of the orbit; those which commence in the cavities close to the orbit; and those which originate in some vascular disease within the cavity of the orbit or the neighboring portions of the cranial cavity, and which usually lead to the symptom of *pulsating exophthalmos*.

Two classes of tumors, namely, those which arise from the optic nerve and those which arise from the lacrimal gland, are sometimes included among the orbital growths. They have already been discussed in another section.

The *nature* of orbital tumors is either benign or malignant, and they may be congenital or acquired, primary or metastatic.

**Symptoms.**—These vary according to the position, size and density of the tumor, but in general terms are those which have been narrated as more or less common to all diseases of the orbit. With regard to the protrusion it may be said that a tumor within the cone of the recti muscles is apt to cause a forward displacement of the globe, while one situated outside of this cone may displace the eyeball in some particular direction (Berry).

Considerable proptosis may occur under the influence of an orbital tumor without causing the globe to protrude between

the fissure of the lids. This is due to the fact that the lids are extensible and accommodate themselves to the increasing volume behind them; finally, however, in bad cases the protrusion is so great that the lids can no longer close over the prominent ball.

**Prognosis.**—This depends upon the nature of the tumor, the density of its tissue, the rate of its growth, and the availability of surgical interference.

**Treatment.**—Morbid growths of the orbit, except some of those which originate in vascular disease, usually must be managed according to the rules of general surgical practice. In dealing with benign tumors, and some encapsulated sar-



FIG. 188.—Metastatic sarcoma of the orbit (from a patient under the care of Dr. Wharton in the Children's Hospital).

comas, the eyeball, if uninvolved, should be allowed to remain, if possible; but if the tumor is malignant, the eye should be excised, in most instances, with the entire contents of the orbit (see chapter on Operations). As has been pointed out by Panas, Snell, and others, certain apparently organic tumors of the orbit, probably lymphomas, occasionally disappear under medicinal treatment—for example, iodid of potassium, arsenic, etc. Hence the necessity of careful medication before surgical measures are tried.

**1. Tumors which Originate in the Tissues of the Orbit.**—These include cysts, fibromas, cavernous and simple angio-

mas, lymphangiomas, lipomas, enchondromas, lymphomas, and various types of sarcoma. Carcinoma, except in connection with the lacrimal gland, does not occur in this situation as a primary tumor; it may, arising from the lids or conjunctiva, grow inward and involve the orbit.

*Sarcomas* of the orbit may be primary or metastatic and may present the various types of cellular structure characteristic of these tumors. Some sarcomas of the orbit should be classified with the *endotheliomas*. If the morbid process is an extensive one, radical removal of the entire contents of the orbit is the only procedure. Encapsulated sarcomas may occasionally be removed with preservation of the eyeball. *Traumatic sarcomas* offer a most unfavorable prognosis, and operation hastens rather than retards the fatal issue. Sarcomas of the orbit should not be confounded with those which arise within the eyeball and have burst their boundaries (page 396).

Berlin divides *orbital cysts* into two principal groups, *cephaloceles* and *true cysts*. Cephaloceles are located at the root of the nose, and extend to the brow, nasal cavities, or orbit. Characteristic of cephaloceles and meningoceles is the fact that they present at the inner side of the orbit, that they fluctuate and are transparent. True cysts should be divided, according to Klingelhoffer, into (*a*) true cysts from constriction, which are derived from congenital meningoceles; (*b*) extravasation-cysts—that is to say, blood-cysts, hematomas, etc.; (*c*) exudation-cysts, which are very rare; (*d*) dermoids, which are the most frequent cystic tumors growing in the orbit; (*e*) mucous cysts, which may communicate with the nose, and (*f*) echinococcus cysts. Extravasated blood in the retrobulbar tissue may become encapsulated and simulate a blood-cyst.

Occasionally a simple incision suffices to cure a cyst if the cavity is afterward frequently syringed with an astringent or antiseptic lotion. After the evacuation of a dermoid cyst, Buller recommends the introduction of a crystal of nitrate of silver or tincture of iodine to destroy the cyst-wall. If semi-solid or solid contents are present, entire removal is necessary.

Care must be taken not to confound a cephalocele with an orbital cyst.

**2. Tumors which Arise from the Periosteum or Bony Walls of the Orbit.**—These include :

- (a) *Sarcomas*, which arise from the periosteum.
- (b) *Thickening of the periosteum*, which may simulate a true tumor, especially if the underlying bone is hypertrophied (hyperostoses : these may be multiple or diffuse), and—
- (c) *Exostoses*.—The latter are very hard tumors having an ivory-like shell and a nucleus of spongy bone, their anatomic structure in general being like that of the osteomas proceeding from adjacent cavities.<sup>1</sup> All orbital osteomas grow slowly—the external exostoses more slowly than the bony tumors which originate from the frontal and ethmoid sinuses. They spring from the periosteum, and are generally found at the upper border of the orbit, although they may occur at any portion of the orbital border, and are recognized by their dense hardness and evident connection with the bone.

They may arise from injury ; sometimes they are congenital, and often their origin is obscure.

The operation for the removal of an exostosis, after its exposure by suitable incisions of the soft parts and periosteal covering, consists in drilling it away at the base and completing the separation by means of a hammer and chisel. The operation is attended with considerable risk.

**3. Tumors which Arise in Cavities or Tissues Close to the Orbit.**—These include :

- (a) *Encephalocele*, a rare condition, which appears in the form of a somewhat pulsating, fluctuating protrusion at the inner angle of the orbit ; it is of congenital origin (see also page 641).
- (b) *Nevi*, *epithelioma*, and *lupus*, which may extend from the skin of the face into the orbit.
- (c) *Polypi* from the nasal chambers and surrounding sinuses, and—
- (d) *Osteomas* of the frontal and ethmoid sinuses.

<sup>1</sup> For a valuable paper by J. A. Andrews, on "Osteomas of Orbit," see *Medical Record*, September 3, 1887.

An *osteoma* consists of a dense growth, with predominance of the ivory-shell, and only a trace of spongy tissue (occasionally the reverse occurs). Generally the surface is covered with a delicate connective-tissue envelop, and part of this may be the seat of polypoid growths coming from the remains of the mucous membrane which atrophies under pressure of the tumor.

According to Andrews, osteoma of the frontal sinus first makes its appearance by a tumor at the upper inner angle of the orbit, and may be associated with the formation of polypi and suppuration of the sinus.

One which grows from the ethmoid sinus first appears at the inner angle of the orbit, and the eyeball is displaced laterally.

If an osteoma springs from the antrum of Highmore, the tumor appears behind the lower eyelid, and the eyeball is displaced upward; if it arises in the sphenoid fissure, sight is affected by compression of the optic nerve.

Extirpation of osteomas in the sinuses is attended with considerable risk, and a number of fatal cases are upon record.

**4. Tumors which Originate in some Vascular Disease within the Cavity of the Orbit or in the Neighboring Portions of the Cranial Cavity (Pulsating Exophthalmos).**—Under the name pulsating exophthalmos a number of conditions of diverse origin have been recorded. In typical cases the symptoms are: protrusion of the eyeball, with pulsation (vascular protrusion of Nunneley) which may be bilateral, a distinct bruit over the eye and forehead, passive hyperemia of the veins of the eyelids and subconjunctival tissue, as well as those of the retina, the latter often being unusually distended and tortuous; occasionally optic neuritis and retinal hemorrhages. Stooping forward increases the protrusion, the fulness of the vessels, and the pulsation. The subjective symptoms are tinnitus aurium, noises in the head, and pain, all of which may be modified and sometimes checked by pressure upon the carotid artery.

Formerly such symptoms were regarded as evidence of



true aneurysm of the ophthalmic artery, but pulsating exophthalmos may also be due to a vascular tumor or an intracranial affection. As Rivington demonstrated, the affection may be caused by an extra-orbital aneurysm of the ophthalmic artery, aneurysm of the internal carotid, or an aneurysmal varix involving the internal carotid and the cavernous sinus. The last-named lesion—arteriovenous communication—is the one most frequently responsible for these phenomena. Dilatation from obstruction of the ophthalmic vein may cause the condition, but aneurysm by anastomosis, which may involve the orbit by spreading from neighboring parts, is not accompanied by exophthalmos. Traumatism is responsible for the majority of the cases, being the essential cause in about 60 per cent.

**Treatment.**—Compression of the common carotid, with or without the administration of iodid of potassium, may be tried. In the event of failure, the common carotid should be ligated, and a favorable result may be expected in the majority of cases. In a few instances electrolysis has yielded good results, and in one or two instances spontaneous cure is said to have occurred.

**Exophthalmic Goiter** (*Graves's Disease* ; *Basedow's Disease*).—This disease, when it is perfectly developed, is characterized by three cardinal symptoms—enlargement of the thyroid gland, palpitation of the heart, and prominence of the eyeballs. As the affection should be classified with diseases of the ductless glands, the student is referred for a full consideration of the subject to treatises upon the practice of medicine.

Inasmuch, however, as one of the cardinal symptoms—prominence of the eyeballs—is a very marked one, and as there are certain changes seen especially in and around the eyes, a few words may be added. Exophthalmos varies from a mere prominence of the eyeballs, such, for instance, as is noticeable in a highly myopic globe, to a degree of protrusion so great that the eyelids are unable to close. Three symptoms should be searched for :

1. *Von Graefe's sign*, which is very important in the early recognition of the disease. Normally, when the globe is turned

downward, the upper lid moves in perfect accord with it; in this disease, on rolling the eyeball downward, the upper lid follows tardily, or does not move at all. The symptom is not always present, but it may be noted prior to any exophthalmos or at least when there is only a very trifling degree of this, and it persists after the protrusion of the eye has subsided.

2. *Stellwag's Sign*.—This consists of imperfect power of winking or diminished frequency in the act; thus, there may be a number of rapid winks, succeeded by a long pause in which there is no movement of the lids, or each time that nictitation occurs, it is not complete and the margins of the lids do not, as in the normal eye, come together.

3. *Dalrymple's Sign* (Cooper-Swanzy).—This consists of retraction of the upper eyelid so that there is an unnatural degree of separation between the margins of the two lids. The widening of the palpebral fissure produces the peculiar stare which is present in the subjects of exophthalmic goiter, and which has been compared to a similar appearance produced by the action of cocaine.

**Changes in the Cornea.**—The exposure to which the eye is subject and also the paralysis of the nervous supply may cause drying of the epithelium of the cornea, and ulceration of so violent a type as to produce destruction of the eye. New vessels may develop in the lower part of the cornea on account of its exposure through the widened palpebral fissure. These corneal changes necessarily occur in severe types of the disease where the protrusion of the eyeballs has been considerable.

**Ophthalmoscopic Changes.**—These are not commonly present to any great degree except in so far as a change in the size of the retinal vessels is concerned. The arteries may be dilated and assume a caliber larger than normal and equal to that of the veins. Spontaneous arterial pulsation is frequently present (Becker). Alterations in the optic nerve and in the general fundus are not usually found, and there are no changes in the eye-grounds characteristic of the disease.

**Nature of the Disease.**—The theory which has ascribed

Graves's disease to a lesion of the cervical sympathetic causing paralysis of the vasomotor nerves, does not at the present time receive the support that it formerly enjoyed. By some authors the affection is attributed to a central lesion in the medulla oblongata, by others to disturbed function of the thyroid gland.

**Treatment.**—For the general treatment of exophthalmic goiter the student is referred to the text-books on general medicine and neurology. Sympathectomy has been practised for the relief of these exophthalmos. If ulceration of the cornea occurs, the usual treatment is applicable. To prevent the exposure of the cornea, the widened palpebral fissure may be narrowed by the operation of tarsorrhaphy (see Fig. 203).

**Affections or Diseases of the Sinuses.**—In discussing tumors of the orbit, it was noted that growths from the frontal sinuses, the sphenoid fissure, the ethmoid cells, and the antrum may encroach upon the orbit. In addition to the morbid growths there remain to be briefly considered:

1. **Diseases of the Frontal Sinus.**—This is most often a distention of the frontal sinus by mucus (*mucocoele*) or pus (*empyema*). Abscess has been attributed to postnasal catarrh, syphilis, tuberculosis, and periostitis, and is due to the stoppage of the normal outlet, thus causing the accumulation of secretion until the sinus becomes filled, its walls distended and thin, and a tumor presents, usually at the upper and inner angle of the orbit. It may occur under the influence of erysipelas, acute infectious diseases, and epidemic influenza. Sensitiveness on pressure over the frontal bones and frontal headache or supra-orbital pain are common and somewhat characteristic symptoms. The protrusion may cause displacement of the eyeball downward and outward and diplopia, and the pressure upon the lacrimal sac, epiphora. Coryza and purulent discharge from the nostril may be present. According to Bull, if a dense, hard swelling appears at the upper and inner angle of the orbit, which is slow in growth and painless, an osteoma of the sinus is almost certainly present. In rare instances the abscess in the sinus is bilateral.

It is a chronic disease and occurs at any age except before the sixth year, because the sinus is not much developed until after that time of life. It is most frequent between twenty-five and thirty, and commoner in men than in women.

The treatment consists in opening the abscess and washing out the sinus with a bichlorid solution. The incision may be made immediately beneath the superior orbital arch, directly outward, so that the bony wall of the sinus, which is here very thin, may be easily opened, if it has not already perforated (Bull). The contents of the cavity should be carefully removed. The communication between the sinus and the



FIG. 189.—Introduction of drainage-tube after evacuation of abscess caused by ethmoiditis.

nose should then be re-established, and a drainage-tube passed from the orbit, through the opening, into the nose. This tube must be worn until the cavity has sufficiently contracted to justify its removal. Frequent antiseptic irrigations through the tube should be practised.

**2. Disease of the Ethmoid.**—A common disease of the ethmoid cells is caused by a retention of secretion in them—that is, adopting Knapp's phraseology, a *retention-cyst* develops. Under these circumstances the growth appears at the upper and inner angle of the orbit, above and behind the internal canthal ligament, and displaces the eyeball downward and outward. It may not be possible to differentiate this *mucocele*.

from an exostosis until an exploratory incision is made. With ethmoiditis there may also be tumefaction, especially of the inner third of the lid, imperfect movement of the eyeball with diplopia, severe neuralgic pain, and profuse lacrimation. The last-named symptom may cause the affection to be mistaken for dacryocystitis. In purulent disease of the ethmoid cells the natural escape for the pus is into the nasal cavity, where it can be seen beneath the middle turbinated body, or between this structure and the septa; but, as Bosworth remarks, this is by no means its invariable course. In a large number of cases pus escapes through the os planum into the orbital cavity, giving rise to exophthalmos and *orbital abscess*. The purulent collection should be evacuated by a free incision, so placed as to expose the os planum of the ethmoid. After all necrotic and carious tissue is removed, an opening should be forced into the nose. Through it a drainage-tube should be passed, by means of which the cavities can be frequently cleansed with a bichlorid or other antiseptic solution.

*Fistula of the orbit*, presenting above the internal canthal ligament, may be due to disease of the frontal sinus or of the ethmoid, and particularly to disease of the lacrimal division of the anterior ethmoid cells. Cases of this character are often mistaken for lacrimal disease, and, in fact, they present some of the characteristics of the so-called prelacrimal sac abscess. A cure may be effected by forcing with a strong probe, as Gruening has suggested, and opening through the base of the fistula into the nasal cavity, thus facilitating drainage through the nose.

**3. Disease of the Sphenoid Sinus.**—Empyema of the sphenoid sinus may exist alone, or more often in association with suppuration in the ethmoid cells, and may appear in an *acute* or *chronic* form. It is of particular ophthalmologic interest on account of the intimate relation between the walls of the sphenoid cavity and the optic nerve, and an almost necessary symptom is some form of optic neuritis, either retrobulbar or localized in the nerve-head itself. As Gifford has remarked, obscure optic-nerve disease should lead the surgeon to take the sphenoid sinus into serious account.

Other diseases of this region are *polypi*, *osteomas*, and *hyperostoses*.

**4. Disease of the Antrum.**—Empyema of the antrum is not an uncommon affection, and although it does not belong to the domain of ophthalmology, it is sometimes accompanied by marked ocular signs. In addition to the pain located in the cheek, frequently periodic in character, together with the escape of pus from the antrum, there may be a marked edema



FIG. 190.—Exophthalmos from tumor of antrum which involved the orbit (from a patient in the Jefferson Hospital under the care of Dr. J. Chalmers DaCosta).

of the lids, which, if the disease is of long standing, assumes a positively brawny consistency. Dr. Walter Freeman informs the author that he has seen this edema of the lids when only a few drops of pus have been present in the cavity of the antrum. There may also be chemosis of the conjunctiva and some edema of the optic nerve and overfilling of the retinal veins. A persistent edema of the eyelids not otherwise explained should lead the surgeon to make a thorough examination of the antral cavity. A certain number of cases

of lacrimal disease presenting in the ordinary forms of dacryocystitis are connected with antral affections.

Growths in the antrum—*sarcoma*, *fibroma*, and *polypi*—may involve the orbit and produce exophthalmos, or more often displacement of the eyeball upward and outward.

Although the ocular manifestations of sinus disease are often marked, it should be remembered, as Sattler points out, that excessive dilatation of the pneumatic sinuses of the skull may pursue an entirely latent course and cause no very decided eye symptoms.

**Injuries to the Orbit.**—These include fracture of its bony walls, penetrating wounds, the lodgement of foreign bodies, and contusions. The effects of an injury to the orbit depend very much upon the character of the wound and missile which has produced it. The injury may lead to a phlegmonous inflammation, to hemorrhage within the tissues, and to loss of sight by rupture of the eyeball or injury to the optic nerve. There are likely to be, according to the circumstances, exophthalmos, displacement of the eyeball, and diplopia.

*Hemorrhage in the orbit*, especially beneath Tenon's capsule, will be referred to again as an accident which complicates strabismus operations. It may also occur in the course of certain diseases—*e. g.*, scorbutus and hemophilia.

**Treatment.**—After a penetrating wound a careful search for a foreign body should be made. In a number of instances extraordinary foreign bodies have been found in the orbit, and, curiously enough, very remarkable toleration of the presence of such bodies. If the penetrating wound has cut off the attachment of one of the ocular muscles and the case is seen soon enough, an endeavor should be made to suture the detached ends. In cases of excessive hemorrhage within the orbit it may be necessary to make an incision and remove the escaped blood.

**Dislocation of the Eyeball.**—The eyeball may be luxated from between the lids, which are then contracted behind it. It is a rare form of injury. The result of such an accident may be laceration of the optic nerve and destruction of sight.

In other instances the vision has remained unaffected. In certain cases of exophthalmos it is possible to produce this dislocation by pressure upon the globe with the thumbs, the relaxed muscles permitting the eyeball to protrude between the lids. The eye should be replaced and bandaged, preceded, if necessary, by division of the external commissure.

**Enophthalmos**, or retraction of the eyeball, occurs both as an idiopathic and a traumatic affection. Enophthalmos the result of exhausting diseases is more apparent than real, but a true sinking of the globe, producing an appearance not un-



FIG. 191.—Traumatic enophthalmos, patient looking straight forward; sunken appearance, resembling a badly fitting artificial eye, well shown.

like that caused by a badly fitting artificial eye (Nieden), may follow a traumatism in the neighborhood of the orbit.

This retraction of the eyeball may immediately follow the injury, or be delayed for days or even months. According to the conditions which are present, it has been ascribed to paralysis of Müller's orbital muscle from lesion of the sympathetic (Schapringer); to atrophy of the retrobulbar cellular tissue caused by trophic nerve disturbance (Beer); to fracture and depression of the orbital bones with cicatricial adhesion or contraction; and to injury of Tenon's capsule and the check ligaments (W. J. Shoemaker). It may be associated with palsy of the inferior oblique (Fuchs, Sachs).



## CHAPTER XXII.

### OPERATIONS.

THE character of the tissues involved in many eye operations precludes the propriety of employing powerful germicides in the manner in which they are sometimes used by general surgeons, but all the principles of aseptic surgery are applicable in ophthalmic operations. The following directions, based upon those given by Dr. J. William White to his students, have been modified to suit operations upon the eye:

**Preparation of the Hands of the Operator.**—Scrub the hands thoroughly with soap and warm water; then clean the spaces beneath and around the nails; soak the hands in 95 per cent. alcohol for not less than one minute; on removing them place them without drying in a solution of 1 : 1000 corrosive sublimate, and then allow them to remain there for at least one minute.

**Preparation of the Skin of the Region of Operation.**—The skin should be treated first with soap and water, then with alcohol, and finally with corrosive sublimate (1 : 2000). The irritating substances must not enter the conjunctival sac, but the face, surface of the closed lids, eyebrows, brow, and scalp should be thus prepared. The ciliary margins should be carefully cleansed with soap and water, followed by bichlorid of mercury (1 : 5000). The parts should be kept covered with a compress of lint soaked in the bichlorid solution until the operation begins.

The preparation of the conjunctival sac depends upon the nature of the operation; if this, for example, is an enucleation, the ordinary rules of antiseptic surgery are applicable, and the same is true, for instance, in an advancement, save only that the strength of the bichlorid solution commonly employed by general surgeons must be decreased. A solution of 1 grain to the

## Preparation of the Instruments—Dressings 653

pint will suffice. The preparation of the conjunctiva preparatory to cataract extraction is described on page 705.

**Preparation of the Instruments.**—All coarse instruments, such as hooks, scissors, etc., should be cleansed first with soap and water, then boiled, and finally placed in an antiseptic bath, where they remain until required, and they should not be in this fluid for less than twenty minutes before the operation. The antiseptic bath may be carbolic acid (1 : 20) or absolute alcohol, preferably the latter. Finally, they are transferred to a tray filled with sterile water.

Sharp instruments—cataract knives, keratomes, cystotomes, etc.—must be cleansed with great caution lest damage be done to their edges. First the edge of the instrument is inspected with a magnifying-glass, then the instrument, wrapped in cotton, is put into boiling water for five minutes, and from this transferred to a dish containing absolute alcohol, and finally to a vessel of sterile water, where it remains until the operator is ready to use it. As boiling is likely to spoil the edges of sharp instruments, Stroschein believes that it is sufficient to rub them with cotton-wool soaked in a mixture of equal parts of alcohol and ether, and subsequently to wash them in a 5 per cent. solution of carbolic acid. Instead of transferring the instruments after boiling them to absolute alcohol or carbolic acid, they may be placed directly in a bath of sterile physiologic salt solution, or simply sterile water, until they are needed for the operation. Perfect sterilization of non-cutting instruments may be obtained by having them made of platinum and bringing them to a white heat in the flame of a lamp just before the operation (Gruening). Recent investigations by E. A. de Schweinitz, H. O. Reik, and W. J. Watson indicate that the vapor of formaldehyd is of practical value for disinfecting small instruments.

**Dressings.**—These must be modified according to circumstances. In plastic operations about the lids the ordinary dressing—that is to say, steam- or heat-sterilized gauze—may be applied, held in place with a sterile gauze roller. The author fails to see any advantage of iodoform under these circumstances, although it has been advised by some

surgeons. Iodoform gauze is occasionally useful in packing the orbit after evisceration, although here also ordinary sterile gauze yields satisfactory results.



FIG. 192.—Figure-of-eight of one eye. FIG. 193.—Figure-of-eight of both eyes.

If a wet dressing is desired, the fabric may be soaked in bichlorid solution, 1 : 5000, saturated boric acid solution, or



FIG. 194.—Modified Liebreich's bandage.

in a physiologic salt solution which has been sterilized by boiling, the last preparation being especially valuable if skin-

grafting has been employed. Bits of gauze prepared by sterilization with steam are much more desirable than cotton for removing blood, etc., from the area of operation. The various dressings used after cataract extraction, iridectomy, etc., will be described in another section (see page 712).

When the eye is bandaged, either the single or double gauze bandage is employed, or a modification of Liebreich's bandage.

**Sutures.**—These may be of catgut or of silk. Black silk sutures are often useful, as they are more easily seen when the time comes for their removal; in other respects, however, they possess no advantages over white silk, of which, indeed, better and stronger qualities can usually be obtained. It stands to reason that all sutures before their use should be properly sterilized.

**General Anesthesia.**—The indications for general anesthesia in ophthalmic surgery are limited. In children or in very nervous adults, and for enucleations, blepharoplasty operations, occasionally in advancements of the muscles, and in most cases of glaucoma, general anesthesia is necessary. The surgeon must decide between ether and chloroform.

The author prefers to use the former, as it is safer than chloroform or the mixture of chloroform, ether, and alcohol. Bromid of ethyl has been recommended. The author has not been favorably impressed with this anesthetic.

**Local Anesthesia.**—1. **Cocain.**—Hydrochlorate of cocain is usually employed in a 2 or 4 per cent. solution. A 10 per cent. solution has been advised in the operation of curetting lupus and similar growths. General anesthesia is more satisfactory. Cocain causes drying and roughening of the corneal epithelium. This may be partly avoided by keeping the lids closed after each instillation. The drug should not be used too freely, or it may, according to Mellinger, prevent closure of the corneal wound. Gelatin discs impregnated with cocain, as recommended by some surgeons, have no advantage over a solution of the drug. Various fungi grow readily in solutions of this alkaloid, and, indeed, in solutions of any of the alkaloids commonly used in ophthalmic practice. A number of methods

of sterilization are employed—namely, sterilization by heat, by the addition of an antiseptic (a 1 : 5000 solution of bichlorid of mercury, 4 per cent. of boric acid, formic aldehyd, as recommended by Valude, or trikresol, 1 : 1000, as suggested by Dr. E. A. de Schweinitz, of Washington), or by the combination of these two methods. The best method, however, is to



FIG. 195.—Flask for sterilizing collyria.

boil the solution. A number of convenient flasks designed for this purpose are on the market, among the best being those introduced by Dr. Stroschein, of Würzburg, and the one devised by Llewellyn, of Philadelphia (Fig. 195). The solution is placed in the latter flask and boiled. After the liquid is cool and ready for use, the warmth of the hand causes the fluid to drop from the end of the pipet. If it is desired to

preserve the solution after boiling, a portion of one of the antiseptic substances previously mentioned may be added. Boiling is apt to decompose cocain and destroy its anesthetic value.

2. **Eucaïn** may be obtained in the form of hydrochlorate of eucaïn "A," which in 2 per cent. solution is an efficient anesthetic, but produces disagreeable congestion of the conjunctiva, and in the form of hydrochlorate of eucaïn "B," which is related to eucaïn "A," and also to cocain and tropacocain. It is not decomposed by boiling, and in 2 per cent. solution is an active anesthetic which does not dilate the pupil and is said not to cause clouding of the corneal epithelium.

3. **Holocain.**—A 1 per cent. solution of this drug causes anesthesia in from fifteen seconds to one minute, which lasts for about ten minutes, preceded by a moderate burning sensation. It is an admirable local anesthetic, and its solution does not enlarge the pupil, does not affect accommodation nor increase intra-ocular tension, and is said to possess bactericidal properties (Randolph). It is preferred by many surgeons to cocain in operations on the eyeball—for example, cataract extraction. Its value as an application to corneal ulceration has been described.

**4. Acoïn.**—This drug is related to caffein and theobromin, and, according to Randolph's experiments, is an active local anesthetic in unirritated eyes in solutions of 1 : 100 and 1 : 300. It has no effect upon accommodation, the size of the pupil, and does not increase intra-ocular tension or cloud the corneal epithelium. In congested eyes even repeated instillations of acoïn do not produce satisfactory anesthesia. By some continental observers it has been advocated as an anesthetic to prevent the pain of subconjunctival injections. The author fails to see what possible advantage it can have over cocain in this respect.

**5. Dionin.**—This is a morphin derivative which in 5 per cent. solution (stronger solutions are said to be unstable) produces, a few seconds after its instillation into the conjunctival sac, smart burning, followed by marked edema of the conjunctiva. Within a half-hour this edema subsides and anesthesia appears, which is said to last from a few hours to twenty-four or thirty-six hours. It has been employed to relieve the pain of corneal ulcerations, iridocyclitis, and glaucoma. It should not be used in operations to produce anesthesia of the cornea because it is said to produce a tendency to striped keratitis. The author's experience with the drug has been unsatisfactory.

With **peronin**, which is related to benzol and morphin, and has an anesthetic as well as a myotic action, and which has been advocated abroad in glaucoma, the author has had no experience.

**Infiltration Anesthesia.**—In lid-operations cocain solution (2 to 4 per cent.) or eucain "B" solution may be injected beneath the skin (holocain cannot be used for this purpose), but probably a more efficacious and safer procedure is the so-called infiltration anesthesia introduced by C. L. Schleich. This consists of an *intracutaneous* (not subcutaneous) injection with a hypodermic syringe, or with one specially devised for the purpose, of a 0.2 per cent. solution of sodium chlorid, which is reinforced by the addition of from  $\frac{1}{100}$  to  $\frac{1}{50}$  of 1 per cent. of cocain. The fluid injected produces edema, and the anesthesia is strictly limited to the edematous area.

**Local Hemostasis.**—For the purpose of producing a

hemostatic and astringent action the surgeon may employ various preparations of the *suprarenal capsule*, as originally suggested by Dr. Bates, of New York. A mixture containing one part of the dried and powdered gland and 10 parts of sterile water, which should be filtered before it is employed and freshly prepared for each occasion, is satisfactory. A few seconds after its use a congested mucous membrane is blanched almost to whiteness.

Another preparation of suprarenal gland much used abroad is *atrabilin*, which may be employed in its pure state, or mixed with boric acid—for example, in the proportion of 2 grams of atrabilin, half a gram of boric acid, and 10 grams of distilled water.

The most elegant preparation of suprarenal gland, however, is a principle which has been separated by Dr. Takamine and which can be obtained in the form of *adrenalin chlorid*. It is efficacious in a solution of 1:10,000, and is active in even weaker solutions. These remedies are valuable in controlling hemorrhage during slight operations on the eye—for example, tenotomies, excision of pterygia, and will temporarily blanch a congested conjunctiva. Their therapeutic indications have been referred to elsewhere.

#### OPERATIONS UPON THE EYELIDS.

**Epilation of the Eyelashes.**—Removal of the lashes is performed with forceps known as *cilium forceps* (Fig. 196).



FIG. 196.—Cilium forceps.

The patient being seated in good light, the operator with the fingers of one hand puts the lid upon a stretch, at the same time slightly everting its border. The faulty cilia are firmly seized and pulled out with a quick motion. After those which are readily seen have been removed, search should be made (with a loupe) for others which may have been broken off, leaving small but irritating ends, and for very fine white hairs which, owing to their lack of color, may escape detection with the unaided eye.

**Removal of a Meibomian Cyst.**—This may be removed by a conjunctival incision. A sharp scalpel and small curet are required.

The lid is everted, and the discolored patch marking the position of the chalazion is made prominent. This is then incised, and the

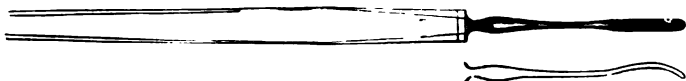


FIG. 197.—Chalazion curet.

contents are scraped out with the curet. The cavity thus formed fills with blood, the absorption of which may be hastened by the use of hot compresses. This operation may leave a slight linear scar in the conjunctiva (Fig. 198).

To avoid this the lid may be grasped between the thumb and

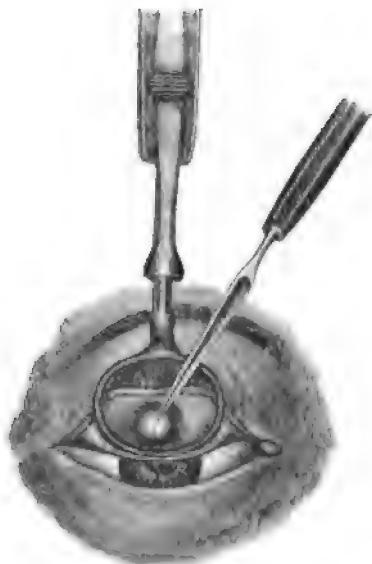


FIG. 198.—Incision of a chalazion (Czermak).

forefinger, and by pressure a drop of the jelly-like contents made to appear at the mouth of the Meibomian duct. A few drops of cocain solution are injected by means of a hypodermic syringe the needle of which is pushed into the tumor along the duct. An incision is now made with a Graefe knife, following the course of the needle.



A small curet is introduced, and the contents of the cyst are removed (Agnew-Ray). The subsequent blood-clot is absorbed.

Although it is usually advised to remove ordinary chalazia from the conjunctival side, a certain number of *external* chalazia are more effectually treated by incision through the skin.

The lid is secured in a clamp (Fig. 199), an incision is made over the tumor along the line of the muscle-fibers and in the natural crease of the lid, and the growth is thoroughly but gently detached from its surroundings on each side, and then, being lifted by means



FIG. 199.—Knapp's lid clamp.

of a small hook, it is separated from its base, care being taken not to perforate the conjunctiva. One or two silk sutures are used to close the wound, and a compress bandage is applied. The sutures may be removed at the end of three days.

**Operations for Ptosis.**—The simplest operation for ptosis consists in removing an elliptic portion of the skin of the drooping lid, together with the hypertrophied subcutaneous fat and connective tissue, and, as Graefe suggested, the subjacent muscle of the lid. The portion which is to be removed is held between two forceps, one being intrusted to an assistant, and the tissue is cut away with scissors; afterward the edges of the wound are transversely approximated. The effect of this operation is usually slight and disappointing.

In congenital or acquired ptosis, when the levator is deficient or entirely paralyzed, the operation of Panas may be practised. A description of this operation follows:

**Panas's Operation.**—The upper lid being steadied by a horn shield, an assistant applies his hand to the brow of the patient to prevent the integument from being drawn down by the surgeon and thus disturbing the relation of the different layers. An incision is made from one canthus to the other, interrupted in its middle to the extent of 8 mm. This incision follows the furrow of separation between the tarsus and the orbital portion of the eyelid. A second horizontal

incision, having its convexity upward and about 2.5 cm. in length, is made just over the orbital margin, and cuts through all the tissues down to the periosteum. Two vertical incisions join this, with the inner extremity of the external portion and the outer extremity of the internal portion of the lower incision. A final incision is then made immediately above the eyebrow, the upper edge of which it follows to the extent of about 2 cm. This incision must cut through all the tissues down to the periosteum. The small cutaneous flap which has been included in the incisions on the lid, and which is evident by a glance at the picture, is dissected free down to the ciliary border. The bridge of tissue between

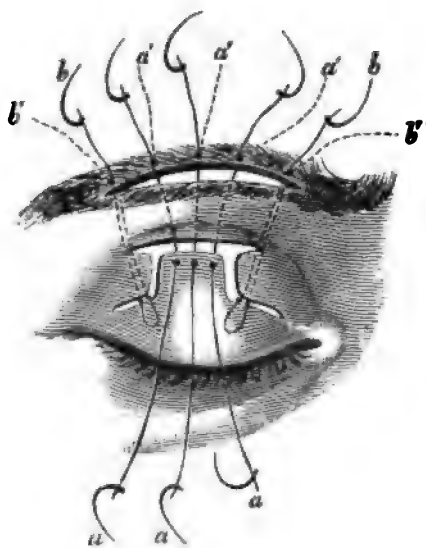


FIG. 200.—Panas's operation for ptosis.

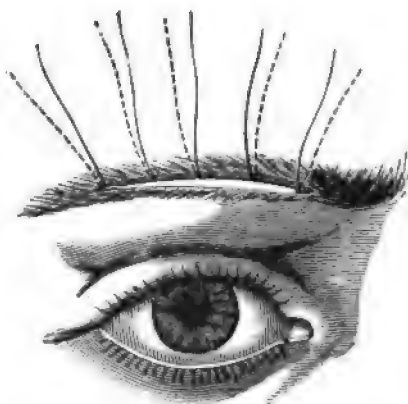


FIG. 201.—Appearance after the operation is completed.

the middle and the upper incisions is then undermined, care being taken not to injure either the suspensory ligament or the periosteum. The dissected flap is then pressed underneath this bridge of tissue and attached by three sutures to the upper edge of the upper incision and the divided fibers of the occipitofrontalis muscle. Two additional lateral sutures are applied in the manner shown in the cut (Figs. 200, 201). These lateral sutures are placed to prevent the dragging which the middle flap might exercise, and thus produce ectropion. These sutures are passed through the suspensory ligament and the conjunctiva, and are attached to the upper margin of the upper incision; they must not pass through the skin of the lid. The wound should be dressed with full antiseptic dressing, and

the sutures may be removed from the fourth to the seventh day, according to the firmness of the union.

Van Fleet has modified Panas's operation in the size and location of the median flap.

J. O. Tansley has designed a combination of the Panas and von Graefe operation, or, rather, according to M. L. Foster, a modification and improvement of Hunt's operation, which the author has followed in several instances with gratifying success:

"Two perpendicular and parallel cuts, A, B, C, D (Fig. 202), one-quarter of an inch apart, are made, and extend from the upper orbital margin to within two lines of the upper edge of the lid. These cuts are

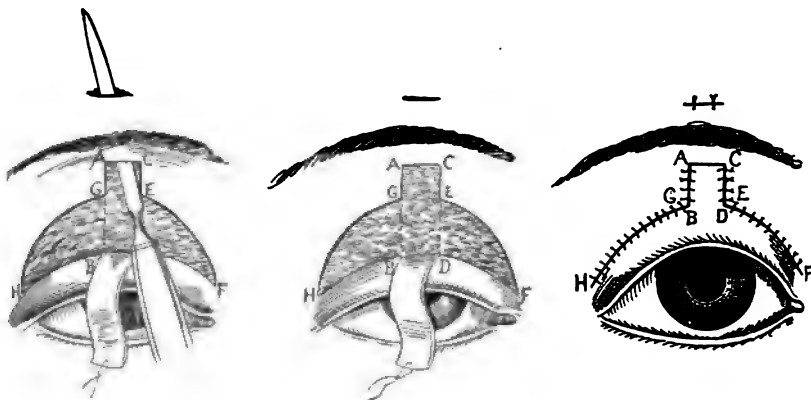


FIG. 202.—Tansley's operation for congenital ptosis.<sup>1</sup>

united at the upper extremity by a horizontal incision, A, C, and the ribbon of tissue is dissected up and permitted to drop down upon a wad of cotton lying on the cheek, which is kept moistened with a warm antiseptic solution. Next, a curved cut is made from H to G and from E to F, following the crease which shows the upper limit of the tarsal cartilage, and a straight cut is made from H to B and from D to F, parallel to and about two lines distant from the lower border of the lid. The skin and the orbicularis embraced within these cuts are now carefully dissected off, leaving the whole tarsal cartilage denuded of tissue. The cut edges H G and E F are united to the cut edges H B and D F, respectively, by interrupted sutures. Next, a narrow Graefe knife is entered at A C, and passed beneath and brought out upon the forehead just above the eyebrow, and slight lateral cuttings are made so as to give room for the pas-

<sup>1</sup> *Trans. Am. Ophth. Soc.*, 1895.

sage of the ribbon of skin which has been dissected up at the first stage of the operation. A strong suture placed in the upper edge of this ribbon of skin is used to draw it up into the cut made beneath the eyebrow and bring it out upon the forehead. When it is drawn up sufficiently tight, it is cut off smooth with the forehead and fastened there by two small sutures. Then several sutures are placed from A to G and C to E, uniting the edges of the ribbon to the bordering derma." The operation can be readily understood by reference to the figure.

Numerous other operations for ptosis have been devised, among which may be mentioned:

**Pagenstecher's Subcutaneous Thread Operation.**—A silk suture armed with two needles is provided. One needle is introduced close to the ciliary border and passed subcutaneously for 2 mm. parallel to the ciliary margin. Next the same needle is reentered at the point of exit and passed between the tarsus and skin and brought out above the brow. The second needle is introduced at the point of entrance of the first and passed upward beneath the skin to the point of exit of the first above the brow. Finally the sutures are tied. This method establishes a contracting cicatrix and is suited to cases of incomplete ptosis.

**Everbusch's operation** is applicable to cases of imperfect action of the levator, and is designed to advance its insertion. The lid is drawn downward and fastened with a Knapp's clamp. An incision is now made throughout the entire width of the lid midway between its margin and the eyebrow, which divides the skin and orbicularis muscle. The edges of the wound are separated for 4 mm. from the underlying tissue above and below, and the tendon, which is thus well exposed, is then included in a loop, with the aid of three double-armed threads passed respectively at the center, the nasal, and the temporal margins. Each needle is now thrust vertically downward between the tarsus and orbicularis, brought out at the free margin of the lid, and securely tied after the wound on the surface of the lid has been closed in the usual manner.

Gillet de Grandmont operates for ptosis by taking out a piece of the cartilage. The lid is grasped in Snellen's clamp, and the amount of elevation needed measured while the patient is looking forward. Next, a semilunar piece of cartilage is removed, the edges brought together, and the skin closed over it. The width of the piece removed corresponds at the highest point of its convexity to the amount of elevation required. This operation receives the commendation of Dr. G. C. Harlan.

Dr. W. H. Wilder, of Chicago, has designed an operation

for ptosis which consists in folding upon itself the tarso-orbital fascia, and by establishing a firm adhesion between the fascia and the frontalis muscle.

**Tarsorrhaphy.**—This operation is performed to shorten an abnormally wide palpebral fissure. The steps are as follows:

The external commissure is taken between the thumb and index-finger, the fissure of the lids closed to the required amount, and the

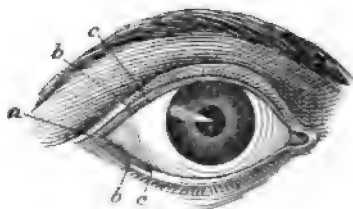


FIG. 203.—Tarsorrhaphy (Meyer).

line of incision marked with an anilin pencil. A horn spatula or shield is now introduced between the lids, and a flap removed from the free margin of each lid near the external commissure; this must contain all the hair-follicles. The breadth of the flap is 1 mm. and the length about 4 mm. To obtain still firmer union the ciliary margin may be denuded for several millimeters beyond the point of removal of the flap, but in this incision the cilia must not be injured. The edges are approximated by silk sutures. The accompanying figure (Fig. 203) explains the steps: *a* indicates the point of union of the two flap wounds behind the commissure; *b, b*, the termination of the flap wounds in the lid-margins; and *c, c*, the end of the denudation of the ciliary margins.

**Canthoplasty** (*Blepharotomy*).—This operation is performed to enlarge an abnormally short palpebral fissure.

One blade of a pair of probe-pointed scissors is introduced behind the external commissure, and the entire thickness of the tissues is divided, making the wound in the skin a little longer than that in the conjunctiva. The wound margins are now separated, and the surgeon loosens the conjunctiva at the apex of the incision and frees it from the underlying tissue. Three sutures are passed, one uniting the extremity of the conjunctival flap to the center of the skin incision, and one suture above and one below near the angles of the wound. Division of the external canthus without subsequent introduction of sutures is known as *canthotomy*.

**Operations for Trichiasis.**—If only a few hairs are involved, the offending lashes should be extracted with cilium forceps in the manner already described.

**Electrolysis**, as originally suggested by Michel, of St. Louis, may be performed as follows:

A platinum or iridium needle attached to the negative pole of a constant battery is inserted into the follicle of the lash which is to be removed. A sponge electrode attached to the positive pole is applied to the cheek and the current closed. A drop of froth appears around the needle, which should be kept in place for a few seconds and then withdrawn. The lash will be easily removed.

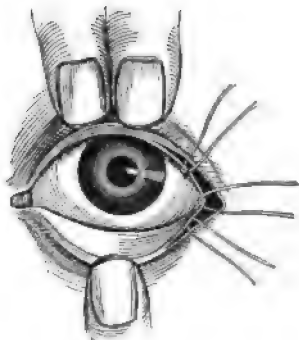


FIG. 204.—Canthoplasty (Meyer).

For complete distichiasis some form of transplantation should be employed.

A useful procedure is the Jaesche-Arlt operation, which is performed as follows:



FIG. 205.—Jaesche-Arlt operation for trichiasis: 1, Intermarginal incision: 2, 3, positions of the second and third incisions, between which the integument is removed (Czermak).

**Jaesche-Arlt Operation.**—The lid is fixed with a Knapp's or Snellen's clamp, or steadied upon an ivory shield placed beneath it (Fig. 205), and its intermarginal portion is split by a first incision into two layers (Fig. 206), the anterior containing all the hair-bulbs. A second incision is made 5 mm. from the margin of the lid, while a third is carried in a curve from one end of the second incision to the other end, and the intervening integument is dissected away.

The margins of the gap are drawn together with fine sutures, and the bridge of tissue containing the hair-follicles is thus shifted away from the cornea. The second incision should go down to the tarsal cartilage, but should not cut through it. In dissecting away the flap of integument the fibers of the orbicularis should not be disturbed. If the flaps, after completion of the operation, look blue and danger of sloughing is apprehended, the parts should be dressed with frequently changed compresses soaked in hot bichlorid solution (1 : 8000) ; otherwise an ordinary antiseptic dressing may be applied.

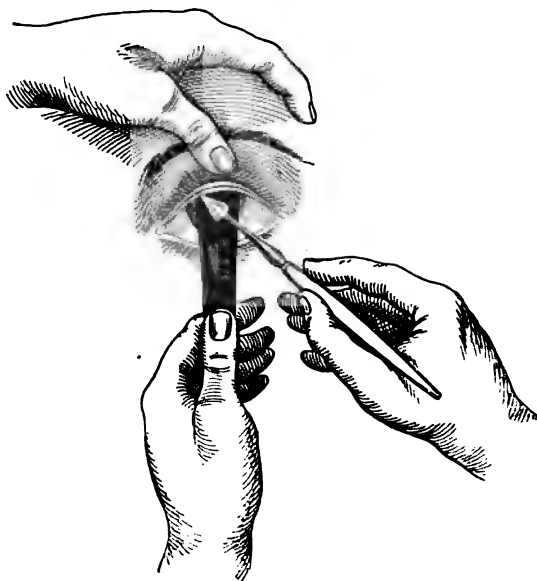


FIG. 206.—Method of making the intermarginal incision (Czermak).

The stitches should be removed at the end of the third day, when union is usually complete.

**Double-transplantation operations**, or, in other words, the manufacture of an artificial lid-border by transplanting a strip of skin to the intermarginal space, have been practised since Spencer Watson's suggestion, especially by Gayet, Dianoux, and Jacobson.

F. C. Hotz, of Chicago, suggests the following valuable method :

The lid-border is split by the well-known intermarginal incision (Fig. 206), after which a transverse incision is made through the lid-

skin and the orbicularis muscle just below and parallel with the upper line of the tarsal cartilage. The strip of muscular fibers which covers the upper portion of the cartilage is excised, and the lid-skin is united with the upper border of the cartilage by three sutures. Each suture passes through the edge of the lid-skin, then through the upper border of the cartilage, and finally through the upper edge of the cutaneous wound. When the sutures are tied, the skin of the lid is drawn upward and fastened to the upper border of the tarsus. By this means a thorough eversion of the anterior edge of the split lid-border is effected, and the intermarginal incision is converted into a gaping wound several millimeters in depth. This groove is filled by a skin-graft, long and narrow and somewhat wedge-shaped, which preferably is removed from the integument behind the ear. It should be from  $1\frac{1}{2}$  to 2 mm. in width, and of a proper length to fill the opening. The graft is spread out, gently pressed into the groove, and after thorough irrigation with a saline solution both eyes are covered with a compress bandage. During

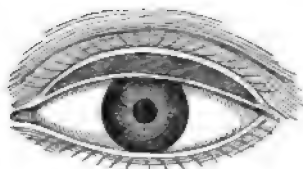


FIG. 207.—Reconstruction of the lid-border (Hotz).

the first two weeks the epidermis of the graft is repeatedly shed, and it is advisable to keep the new lid-border well lubricated with vaselin.

The fine cutaneous hairs in the transplanted flap often irritate the cornea (although Hotz has not experienced this difficulty), and thus vitiate the value of some of these operations. In order to obviate this difficulty Van Millingen proposed his *tarsocheiloplastic operation*, in which the intermarginal gap is covered with a strip of mucous membrane taken from the inner surface of the under lip.

**Operations for Entropion.**—Several methods of correcting spasmodic entropion have been referred to on page 216. In the *spasmodic entropion* of elderly people the following operation may be done:

With entropion forceps a strip of skin of suitable width, parallel to the ciliary border of the lid, is pinched up and excised, together with the subjacent fibers of the orbicularis muscle. The wound is



then closed with silk sutures and dressed in the ordinary way. The sutures are removed on the third day.

Instead of excising a horizontal fold of skin, excision of a triangular portion may be performed (Von Graefe). The base of the triangle is placed 3 mm. from the ciliary margin, and the width and length are according to the looseness of the tissues. After the



FIG. 208.—Cross-bar entropion forceps.

flap is excised the margins are freed and brought together with sutures, but no sutures are applied to the horizontal incision. If necessary, the subjacent tarsal cartilage may be removed.

In organic entropion an operation must be performed which will not merely evert the misplaced border, but also alter the curve of the tarsal cartilage, which usually has become thickened. Two operations will be described :

**Burow's Operation.**—This operation is especially useful for entropion of the upper lid following trachoma. It is performed as follows :

The upper lid is thoroughly everted, and the gray-white scar-line (see page 257) which runs parallel with the margin of the lid is exposed. At the temporal end of this line an incision is made sufficiently large to admit a fine grooved director, which is now pushed to the nasal side of the lid between the skin and the conjunctiva, care being taken that the point of the director is kept well beneath the cicatricial tissue. The tissue thus elevated is divided in its whole length, either with a sharp scalpel or with narrow scissors. When the operation is completed a blue line equal in length to the line of incision should appear upon the cutaneous surface of the lid. No dressing is required, or, at most, cold compresses to allay the irritation. The cicatricial contraction which ensues everts the incurved border of the lid. The operation is always immediately successful, but recurrence of the incurvation is not infrequent ; hence it may be necessary to repeat the operation.

**Hotz-Anagnostakis Operation.**—This operation, as now practised by Dr. Hotz, is described in his own words, as follows :

“ A transverse incision from canthus to canthus is made through skin and subjacent tissues, but, instead of being made near and

parallel with the free border (as in the former methods), the incision in this operation is to follow the *upper* border of the tarsus. It therefore describes a slight curve beginning and ending at a point about 2 mm. above the canthus, but being 6 to 8 mm. distant from the free border in the center of the lid. While an assistant is holding the edges of the wound well separated, the surgeon lifts up with forceps and excises with scissors a narrow bundle of the muscular fibers which run transversely along the upper border of the tarsus. Now the sutures, which are to include nothing but the cutaneous wound borders and the upper border of the tarsus, are inserted. The first suture is placed in the center of the lid; the curved needle, armed with fine black aseptic silk, is passed through the

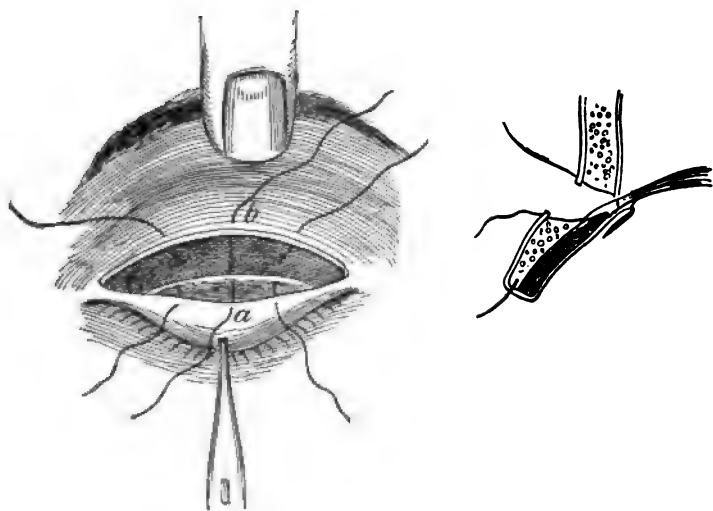


FIG. 209.—Operation of Anagnostakis and Hotz.

lower wound border; there taken again in the needle-holder, it is boldly thrust through the upper border of the tarsus and returned through the tarso-orbital fascia just above this border; and finally it is carried through the upper wound border (Fig. 209, *a*, *b*). One similar suture is placed at each side of the central one, and these three stitches are usually sufficient for our purpose—to wit, to draw the skin of the eyelid up toward the upper border of the tarsus and establish a firm union between these parts. This artificial union produces a slight tension of the tarsal skin, which, however, is sufficient to relieve any ordinary degree of entropion. But when the lids have been badly contracted—when the palpebral aperture has become unnaturally narrow, or the free border of the lid has become entirely merged into the plane of the conjunctiva—these complicated cases require, in addition to the above

operation, such surgical measures as canthotomy, the restoration of the free border either by grooving the tarsus or by grafting" (see Fig. 207).

Although the operations for trichiasis and entropion have been separated in the descriptions, it must be remembered that these two conditions are constantly associated and hence their surgical treatment in most particulars is identical.

**Operations for Ectropion.**—If ectropion is associated with relaxation of the tissues, as is often seen in old people, excision of a V-shaped piece of the whole thickness of the lid may be practised. This procedure may be understood by a reference to figures 210 and 211.

**Snellen's Suture Operation.**—A suture armed with a needle at each end is provided. One needle is entered at the junction of the



FIG. 210.

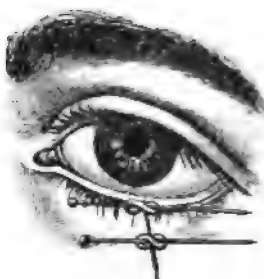


FIG. 211.

FIGS. 210, 211.—Adams's operation for ectropion by excision of a V-shaped piece of the lid (Lawson).

external and middle third close to the posterior border of the tarsus, and is passed down beneath the skin of the lid to a point at the summit of the lower margin of the orbit, and is there brought out. The second needle is entered at a point 5 mm. from the first, and with the other end of the thread is carried down close to the first and parallel with it. The two extremities of the suture are tied upon the cheek over a piece of drainage-tube. The same procedure is repeated with a second double-armed suture, the points of entrance being at the junction of the middle and inner third of the conjunctival surface. This operation is suited to cases of spastic ectropion. It has been employed in senile ectropion, but has under these circumstances no valuable permanent effect.

Ectropion from the contraction of cicatrices, abscesses, etc.,

usually requires a plastic operation (*blepharoplasty*) in which the vicious cicatrix is embraced in an incision. If the scar is small, the operation may be done in the manner indicated in Figs. 212, 213—a method which is known as Wharton Jones's operation.

A horn spatula is put into position to protect the eye, and a V-shaped incision is made. The flap is then separated sufficiently to enable the lid to be pushed up into place. The lower part of the wound is drawn together with sutures, thus converting the V into a



FIG. 212.



FIG. 213.

FIGS. 212, 213.—Wharton Jones's operation for ectropion.

Y. If possible, the triangular flaps must include the cicatrix which has produced the original trouble.

If the cicatrix is extensive, the operation consists in dissecting out the scar, and filling the gap by transplanting a flap of skin from the forehead, temple, or cheek. Many operations of this kind have been devised. The site and character of the lesion will in each instance determine the best method of procedure, and it would not be possible in a chapter of the present scope to indicate in detail the numerous ingenious methods which have been devised for the correction of cicatricial ectropion by these blepharoplastic operations, or for the formation of an entirely new lid to replace one that has been eaten away by some disease, such as lupus.

But in order that the student may have an idea of the formation of the flaps for the relief of the deformities just referred

to, the following figures, taken from Meyer's excellent treatise, are introduced, and reference to them will explain the essential features of these operations.

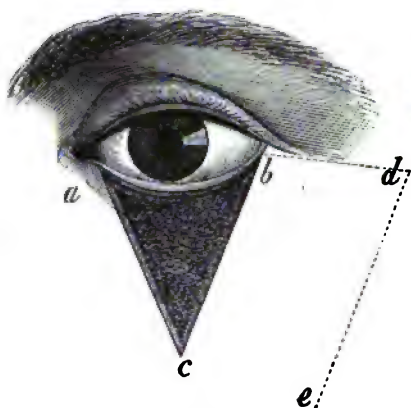


FIG. 214.



FIG. 215.

FIGS. 214, 215.—Restoration of the lower lid by Dieffenbach's method. The diseased tissue has been removed in a triangular flap, *a, b, c*. This defect is covered by a flap taken from the cheek, indicated by the dotted lines, *b-d, d-e*, with the result shown in Fig. 215. The remaining gap may be covered with Thiersch grafts.

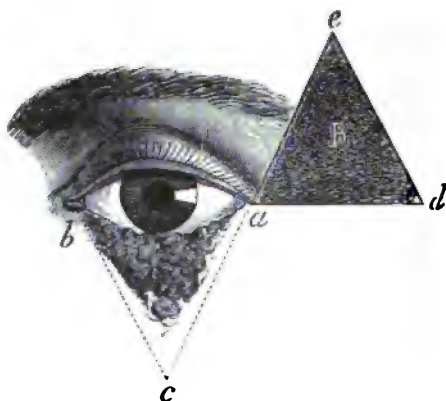


FIG. 216.



FIG. 217.

FIGS. 216, 217.—Restoration of lower lid by Burrow's method. The diseased tissue is removed with the flap *a, b, c*. The horizontal incision is prolonged upon the temple and forms the basis of the triangle *a, d, e*. This flap (*B*) being removed, the cutaneous flap *a, c, d* is dissected up and drawn inward so that the angle *a* is sutured at the point *b*, and *a-d* forms the free border of the lid. *c-a* is now united with *c-b*, and *d-e* with *a-e*, with the result shown in Fig. 217.

During blepharoplastic operations the author is accustomed to irrigate the field of operation frequently with a tepid solution of bichlorid of mercury, 1 : 10,000. When the flaps are in place and the sutures, preferably of silk, are adjusted, the whole area is thoroughly flooded with a sterilized physiologic

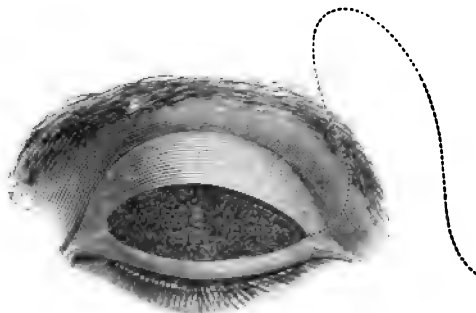


FIG. 218.—Restoration of the upper lid by Fricke's method. The diseased tissue has been removed in an oval flap. The resulting gap is covered by a similarly shaped flap taken from the temple, indicated by the dotted line.

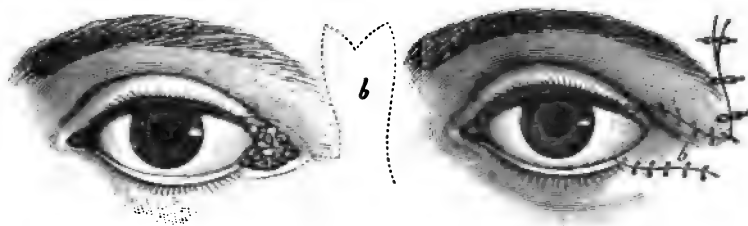


FIG. 219.

FIG. 220.

FIGS. 219, 220.—Restoration of the external angle of the lids by Hasner d'Artha's method. The diseased tissue is removed by two elliptic incisions, and the defect covered with a flap taken from the temporal region at *b*, cut in the manner indicated by the dotted line, with the result shown in Fig. 220. The same operation applies to the inner angle, the flap being taken from the nose.

salt solution. The flaps are now covered with protective, over which several layers of aseptic gauze are placed, care being taken that the gauze itself does not come in contact with the flaps, and the whole is secured with several turns of a sterile bandage. This dressing is undisturbed if there are no signs of reaction for seventy-two hours. At the end of this time it is re-

moved, any exfoliated epithelium trimmed away, and the edges of the flaps anointed with boric acid ointment. Any gap which remains after the flaps are cut and put in position is subsequently covered with Thiersch grafts, and the same method is practised if any portion of the flap of skin should slough. If there is breaking down of the epithelium of the flaps, indicating necrosis of the upper layers, the suggestion of Gifford to scrape the area until healthy bleeding tissue is reached, and then apply a large Thiersch graft, may be followed with advantage, although the necessity for this procedure is more likely to occur in cases in which a flap without a pedicle has been transplanted than when the flaps still retain living connection with the surrounding tissues. Sloughing of the flaps should not occur if care is taken to make them large enough to secure them in position without undue tension, and to prepare them in such a manner that they receive a sufficient vascular supply through their pedicles.

Many disadvantages are associated with blepharoplastic operations, not the least being the extensive scar which may ultimately develop in the position from which the flap was removed. To obviate these a plan originally introduced by Lefort and Wolfe has been practised with success.

**Transplantation without a Pedicle.**—This operation consists in transplanting skin without a pedicle from a distant part, preferably the inner side of the arm or the inner side of the thigh. The flap must be about one-third larger than the spot which it is intended to cover, to compensate for subsequent shrinking. It should be shaved down, so as to be as free as possible from subcutaneous connective tissue and fat, and may be held in place by interrupted sutures. The dressing is exactly the same as that previously described.

The primary effect of these operations is sometimes strikingly good, although as time goes on the transplanted tissue is apt to shrink and is said to disappear altogether. The author has been very much gratified with the operation of transplanting skin without a pedicle in selected cases, particularly after removal of small growths from the lower lid, and after burns causing extensive ectropion of the upper lid.

**Thiersch's Method of Skin-grafting.**—This consists in removing only the upper layer of the skin with a long, wide razor, which is applied flatwise to the inner side of the arm or thigh, and the desired tissue separated by to-and-fro movements with the knife, which is kept flooded with a sterile salt solution. The grafts are

transferred directly from the razor to the area which they are to cover. All bleeding must be stopped before they are put in place. They may be dressed in the manner already described, or, better, surrounded with a lattice-work of protective strips covered with a compress moistened with salt solution. Thiersch grafts, as already stated, are useful as adjuncts to plastic operations. They may be utilized, however, to supply small defects in the lids and to conceal the deformity of burns around the eyes and face. They have been employed after exenteration of the orbit.

#### OPERATIONS ON THE CONJUNCTIVA.

**Operations for Pterygium.**—(a) *Excision.*—The pterygium is seized with a toothed forceps, raised from the surface of the eye, and shaved off with a Beer's knife from its corneal attachment. It is then turned backward, carefully dissected from the underlying tissues, and excised, together with a triangular piece of conjunctiva. This leaves a somewhat diamond-shaped gaping wound in the conjunctiva, which is drawn together with several sutures. If the conjunctiva overlap the corneal margin, two small vertical cuts should be made in it at right angles to the line of excision. After the apex of the pterygium has been separated from the cornea, the vascular subconjunctival tissue must be scraped away down to the sclera; otherwise there will be reattachment. The suggestion of Prince to tear loose the pterygium with a strabismus hook instead of separating the point with a knife is a very good one. Complete excision is not applicable to large nor to fleshy pterygia.

(b) *Transplantation (Knapp's Method).*—This consists in dividing the corneal attachment, turning the pterygium back, and splitting it from apex to base. The ends are then cut off, and each flap is transplanted into its corresponding upper and lower conjunctival wound, and fixed in position with fine sutures. The exposed surface of the sclerotic is covered by first dissecting up and then drawing together the conjunctiva.

Some surgeons remove the growth by strangulating it with a ligature threaded with two needles and introduced beneath the growth under the corneal and sclerotic portions. This method does not compare favorably with either excision or transplantation.

(c) *Subinvolution.*—Bettman has modified Galezowski's method thus: The pterygium is separated from the corneal attachment in the usual way. A suture with a needle at each end is passed through the apex. Both needles are inserted from above downward, thus leaving a loop of thread on its outer surface. The needles are now passed through the base from below outward, the points of puncture being the ends of parallel lines drawn from the punctures of the apex and just far enough back so that when the flap is rolled upon itself the base of the roll will correspond with the corneoscleral margin. The two ends of the suture are now firmly tied. This operation leaves temporarily a somewhat unsightly thickening of the tissues, which is said to disappear in a few weeks.



Large pterygia may be entirely excised and the denuded area covered with a Thiersch flap. This suggestion of Dr. Hotz's the author has followed successfully in a number of instances.

The head of a small pterygium may be destroyed with the actual cautery, and, indeed, this method is applicable to check the growth of any pterygium when other operations described are not desirable or possible. Removal of pterygia with the actual cautery is practised exclusively by some surgeons. The return of a pterygium after excision is not uncommon; occasionally the second growth is thicker than the primary one, and may exceptionally assume a species of keloid formation.

**Operations for Symblepharon.**—An attempt may be made to remedy this condition by dividing the adhesion and

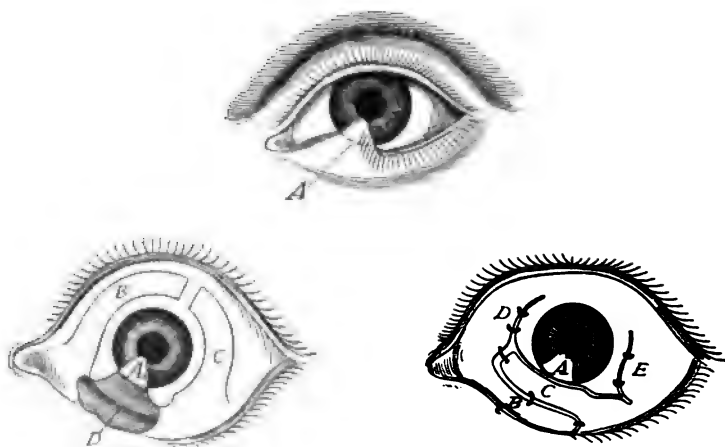


FIG. 221.—Teale's operation for symblepharon (figures from Swanzy). The symblepharon is detached at *A* and removed. Two conjunctival flaps, *B* and *C*, are formed and turned to cover the denuded surface of the eyeball and of the inner side of the lid. The conjunctival gaps are closed by sutures, *D* and *E*.

uniting the cut edges of the conjunctiva with sutures, or covering the raw surface left after severing the adhesions with flaps of healthy conjunctiva taken from the unaffected parts of the eyeball (Teale's operation), or by dissecting back the symblepharon as far as the retrotarsal fold, doubling it upon

itself so as to oppose a mucous surface to the globe, and fixing it in this position by means of a ligature which is armed by two needles and passed through the lid from the conjunctiva outward.

Dr. G. C. Harlan has devised an operation which is applicable to cases in which the whole lid is firmly and closely adherent to the ball, and is thus described by its author :

The adhesion is freely dissected until the upward movement of the ball is entirely unimpaired, and an external incision, represented at *A B* in the accompanying cut (Fig. 222), along the margin of the orbit, is carried through the whole thickness of the lid, which is thus separated from its connections except at the extremity. A thin flap, *C D*, is then formed from the skin below the lid, care being taken to leave it attached at its base line by the tissue just beneath *A B*,



FIG. 222.—Lines of incision in Harlan's operation for symblepharon.

as well as at the extremities. On this attachment it is turned upward as on a hinge, bringing its raw surface into contact with the inner surface of the lid, and its sound surface presenting toward the ball, and held in this position by suturing its edge to the margin of the lid. In dissecting up the flap the incisions are carried more deeply into the orbicularis muscle, when the base line *A B* is nearly reached, to enable it to turn more readily. The bare space left by the removal of the strip of skin is nearly covered without strain by making a small horizontal incision, *D E*, at its outer extremity, and forming a sliding flap.

**Transplantation of Rabbit's Conjunctiva.**—In cases of extensive adhesion between the ball and the lids—such, for instance, as may be remedied by Dr. Harlan's operation—the transplantation of rabbit's conjunctiva has been attempted.

In this operation, after the adhesions have been severed, the raw surfaces are covered by a flap of conjunctiva taken from a rabbit's eye, so removed as to be free from all sub-mucous tissue, and somewhat larger than the defect which it

is expected to cover. It is better to insert the sutures, with which it is afterward put in place, before its removal, as they mark the position of the flap, and at the same time give a means by which it may be transferred from the eye of the rabbit to the eye of the patient. It must be kept warm and moist during the process of transferring it. All bleeding must be stopped before the attachment is made. Instead of utilizing the conjunctiva from a rabbit's eye, mucous membrane may be taken from the lip of the patient. The same result may be accomplished with a Thiersch graft after the manner recommended by Hotz (page 261).

**Operations for Trachoma.**—On page 261 the operative procedures suited to cases of trachoma are briefly described. Two methods require more extended notice :

**Expression (*Knapp's Operation*).**—After the patient is etherized the upper lid is everted, seized at the convex border of the tarsus with a pair of fixation forceps, and drawn away from the eye so as to expose thoroughly the whole palpebrobulbar conjunctiva. If the tissue is infiltrated, it may be superficially scarified, preferably with a



FIG. 223.—Three-bladed scarifier.

three-bladed scarifier (Fig. 223). One blade of the roller forceps (Fig. 224) is pushed deeply between the ocular and palpebral conjunctiva, and the other is applied to the everted surface of the tarsus. The forceps are compressed with some force, drawn forward, and the infiltrated soft substance squeezed out as the cylinders roll over the surfaces of the fold held between them. This manoeuvre is repeated until all the morbid material has been ex-



FIG. 224.—Knapp's trachoma forceps.

pressed—in other words, to use Knapp's expression, until the conjunctiva has been thoroughly milked. The lower lid is treated in the same way. During the operation the surfaces should be frequently flooded with a tepid solution of bichlorid of mercury, 1 : 8000, and after the operation cold compresses may be laid on the lid for twenty-four hours.

The following day the lids should be everted, and usually a delicate grayish layer of lymph will be found covering the entire area of operation. This should be removed, the swollen mucous membrane exposed, and touched in the ordinary way with a solution of nitrate of silver, 5 or 10 grains to the ounce. Each day this treatment should be repeated until the swelling has subsided, when the daily application of a crystal of sulphate of copper is advisable.

The operation should be done thoroughly, care being taken to include the commissural portions of the conjunctiva, and the subsequent local treatment of the case must not be neglected. Expression is especially valuable in cases of spawn-like granulations (follicular trachoma) and diffuse hyaline infiltration. It may be used in cicatricial trachoma when patches of hyaline degeneration are present. If the patient suffers a relapse, as he may, the operation should be repeated. In a somewhat extended experience the author has never seen any save good results from this method of treating granular conjunctivitis. It should never be used in acute trachoma; indeed, usually no form of operative interference is permissible under these circumstances. Some surgeons consider the operation more effective if after the expression a germicide is brushed into the tissues (Weeks).

**Grattage.**—After the patient is anesthetized the conjunctival surface is exposed in the manner already described. The trachomatous tissue is then deeply scarified, the incisions running parallel to the margin of the lid. The surface is next rubbed with the back of the scalpel, and the conjunctiva vigorously scrubbed with an ordinary tooth-brush carrying a solution of bichlorid of mercury, 1 : 2000. If the palpebral fissure is very narrow, canthotomy should precede the operation. The after-treatment consists in measures to prevent adhesions between the folds of conjunctiva and the conjunctival cul-de-sac, and the daily application of a sublimate solution of the same strength as that originally used for at least a week following grattage. The subsequent treatment comprises the usual antiseptic lotions and applications until cure is effected.

This operation is applicable to cicatricial trachoma and cases in the second stage of the disease characterized by sclerotic masses of trachomatous tissue. The reaction is sometimes very severe, and the author has not found this method more efficacious than expression preceded by thorough scarification.

Excision of a strip of conjunctiva containing the trachoma

granules or of the exposed fornix and afterward closing the wound with sutures is practised by some surgeons and highly commended. The author has no experience with this operation.

**Subconjunctival Injections.**—The eye is thoroughly cleansed and anesthetized by the instillation of a 4 per cent. solution of cocain. A fold of conjunctiva is seized with a pair of forceps about 8 mm. from the corneal margin; the point of a hypodermic or Pravaz syringe, charged with the fluid, is now introduced very much in the same manner as when an ordinary hypodermic injection is given, and 2 to 4 minims of the fluid are injected. The strength of the solution varies with different operators. Darier recommended at one time bichlorid of mercury in a strength of 1 : 1000, and that the first dose should not exceed one division of a Pravaz syringe, or, in other words,  $\frac{1}{10}$  of a milligram of the sublimate. He now prefers cyanuret of mercury, which may be used in the same way in a strength of 1 : 1500. If a few drops of a 1 per cent. acoin solution is added to the injection-fluid, the pain which it produces is said to be prevented. Physiologic salt solution is preferable to germicides, as it occasions much less pain and is usually equally efficient. From 10 to 15 minims should be injected (see also page 494). Solutions of hetol (cinnamic acid) in 1 per cent. strength have been used by Pflüger.

These injections are useful in inflammation of the uveal tract and episcleral tissue (iritis, iridocyclitis, and scleritis) and often yield admirable results. They are of less value in chronic inflammations of the cornea (interstitial keratitis), and the author has never seen them accomplish any good in diseases of the retina or optic nerve, nor is his experience with them in choroiditis of a favorable kind, although they have been highly recommended in the treatment of these diseases; certainly there can be no objection to their trial. They are also recommended in sloughing ulcers of the cornea and in cases of infection after operations. They are useful in the treatment of detached retina. Numerous investigations and clinical experiences indicate that the germicide employed has little therapeutic value, as solutions of sodium chlorid act with equal efficiency.

#### OPERATIONS ON THE CORNEA.

**Paracentesis Corneæ.**—The local application of cocain is usually sufficient, but in nervous subjects and young chil-

## Operation of Saemisch : Saemisch's Section 681

dren general anesthesia may be necessary. The operation is performed as follows :

The cornea is punctured near its lower margin, or, in the case of an ulcer, through its floor, with a paracentesis needle constructed with a shoulder to prevent an undue depth of entrance, and inserted at an angle of  $45^{\circ}$  with the point of contact ; or with a broad needle held flatwise, the point being kept well forward so as to avoid wounding the lens. By rotating the needle slightly on its long axis the lips of the opening are separated and the contents of the aqueous chamber more readily escape. The needle must be



FIG. 225.—Paracentesis needle.

withdrawn slowly, lest a sudden gush of aqueous cause prolapse of the iris. The eyeball may be steadied with a spring speculum (see Fig. 227) or fixation forceps (see Fig. 228), provided the former does not put too much pressure on the globe, or the lids may be separated by the surgeon's fingers. If it is necessary to reopen the wound, the probe end of the instrument should be used.

**Application of the Actual Caутery.**—The indications for this application in corneal disease are given on page 294. If possible, a suitable galvanocautery should be employed. If this is not at hand, a platinum probe held by a handle similar to the one which is attached to a laryngoscope mirror will suffice. The operation is done as follows :

A few drops of cocain solution are instilled to produce anesthesia, and the probe or the point of the cautery is brought to a red heat, transferred to the area of disease, and all the sloughing material, and particularly the edge of the ulcer, is gently but thoroughly cauterized. It is not necessary to burn beyond the edge of the ulcer into sound tissue. The extent of the ulcerated area, even to the finest spot characterized by loss of epithelium, may be ascertained by the use of fluorescein, but it should be remembered that this drug also colors, but less vividly, diseased epithelium, and hence is apt to stain the epithelium for some distance surrounding the ulcer. Ulcers with much necrotic tissue on them stain yellow. The separation of the lids with a stop speculum is needless ; in fact, this is disadvantageous on account of the pressure it exerts upon the eyeball. They may be parted by the hands of the operator himself. After the operation the eye may be washed out with boric acid solution, a drop of atropin instilled, and a bandage applied.

**Operation of Saemisch : Saemisch's Section.**—The

upper lid being raised on an elevator by an assistant, the surgeon proceeds as follows :

The conjunctiva below the cornea is seized with fixation forceps, a cataract knife is entered on one side of the cornea, with its cutting-edge forward, carried across the anterior chamber to the other side of the ulcer, and the section made directly through the diseased area, evacuating the collection of pus in the layers of the cornea and at the bottom of the anterior chamber. If the hypopyon is tenacious, this may be removed by inserting a delicate pair of forceps through the incision and seizing the slough, or it may be washed out with a specially devised syringe. If the pus reaccumulates, the wound should be reopened with a probe and the contents of the anterior chamber again evacuated.

A great objection to this operation is the danger of prolapse of the iris.

**Operations for Staphyloma.**—If the measures used to prevent the formation of staphyloma have been unsuccessful (pages 293 and 301), an operation must be done for its relief. In partial staphyloma vision may sometimes be improved by iridectomy, and even by a double excision of the iris, but very often these measures fail, and then its removal may be necessary.

A useful operation for the reduction of the size of a partial staphyloma is recommended by Berry :

A cataract needle is introduced through the base of the staphyloma and held in one hand. An elliptic piece of the cicatricial tissue of which the staphyloma is composed is then cut out by making one incision at the one side of the needle with a cataract knife, and another from the other side, converging toward the first, and in such a manner that the portion held by the needle, and consequently the needle itself, is cut out. The dressing consists of a firmly applied antiseptic bandage, and usually it is necessary to continue the bandage for some time until flattening of the mass has been secured.

After excision of a small staphyloma it is sometimes possible to promote healing by uniting the resulting wound margins with fine silk sutures.

**De Wecker's Method.**—This is suited to complete staphyloma limited to the cornea, and is thus described by its author :

Four sutures should be inserted in the conjunctiva after it has first been carefully detached from the corneal margin almost as far as the equator of the eye. In order to avoid confusion at the moment of

tightening the threads, the precaution should be taken of having them of different colors. The removal of the staphyloma is performed by transfixing it through the middle and cutting outward, then seizing the end of the flap thus formed, and removing the rest with scissors. Care must be taken that the lens escapes from the eye. When this is ascertained, the sutures in the conjunctiva are tightened and the conjunctiva drawn over the wound.

In most instances of complete staphyloma, with participation of the sclerotic, the best operation is enucleation or one of its substitutes.

**Tattooing the Cornea.**—In order to conceal the disfigurement of a dense leukoma it has been suggested to tattoo the white tissue. This is done as follows :

India-ink rubbed up with water into a fine paste is placed close at hand. After the cornea is rendered anesthetic with cocain, the eye is steadied with the fingers, and a drop of the pigment is applied to the surface of the leukoma, and the ink pricked into place with the needles. These needles may be fixed exactly at the same level, precisely as if they were all fastened into a small circular piece of cork, or they may be placed side by side (Fig. 226). Finally a

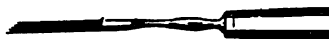


FIG. 226.—Tattooing needle.

single needle, somewhat of the type of an ordinary cataract needle, may be employed, and the pigment pricked into the tissue with little stabs made in an oblique direction. According to Dr. Noyes, the pigment should be prepared by allowing the India-ink stick to soak for several hours in water until it becomes of the consistence of thick paste. A piece of paste equal to the size of the spot to be colored is then placed upon the leukomatous area and pricked into position with the needles. The tattooing should proceed until a uniform black surface is secured. The excess of pigment can be flooded away with a saturated solution of boric acid. It has been suggested by some surgeons to use variously colored pigments in order to attempt to reproduce the colors of the iris.

The principal operations for *conical cornea*, the method of *removing a foreign body* imbedded in the cornea, and the manipulations necessary for closing *scleral wounds* have been described (see pages 320, 322, 333).

#### OPERATIONS UPON THE IRIS.

**Iridectomy.**—The following instruments are necessary : Stop speculum, fixation forceps, bent keratome, iris forceps,



blunt hook, iris scissors, and horn spatula. The preparation of the patient is described on pages 652, 705, 706. The operation is performed thus:

The patient being in a recumbent position and the eye being under the influence of cocain, unless the case is one of glaucoma, when a general anesthetic is preferable, the surgeon separates the lids by means of a speculum, fixes the eye by seizing with forceps the conjunctiva and subconjunctival tissue at a point directly opposite to that of the proposed section, and introduces the lance-shaped keratome in the following manner: The point of the knife

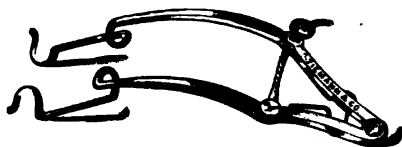


FIG. 227.—Eye speculum.



FIG. 228.—Fixing forceps.



FIG. 229.—Keratome.



FIG. 230.—Curved iris forceps.

is brought into contact with the apparent corneoscleral margin, or, in some instances, about a millimeter from the junction of the sclera with the cornea, and in a direction at right angles to the cornea, which direction it keeps until the point just penetrates the anterior chamber. The handle is then well depressed, so that the point of the knife shall not wound the iris or lens, while the blade is slowly thrust onward until the section is of the desired extent (Fig. 234). The knife is then slowly and cautiously withdrawn, with its point well forward toward the posterior surface of the cornea, so as to allow a slow escape of the aqueous humor and to avoid scratching the capsule of the lens.

The *first stage* being completed, the fixation forceps is handed to

an assistant, who rotates the globe a little downward, if the section has been made upward, and the surgeon introduces the curved iris forceps, expanding the blades so as to grasp the pupillary margin, cautiously withdrawing the forceps with the included portion of the iris, and snipping off the latter close to the wound by one or two cuts with a delicate pair of curved scissors (Fig. 232).

If the anterior chamber is very shallow, it is safer to substitute for the lance-shaped instrument a Graefe cataract knife, making a puncture and counterpuncture, and then cutting in the same manner as when the corneal section in cataract extraction is made (see page 707).

If the section of the iris should cause hemorrhage into the anterior chamber, an attempt may be made to remove the blood by separating the lips of the wound with a metal spatula (Fig. 233) and making very cautious pressure on the cornea, but tritulating movements carried on to any extent are done at the risk of bruising the lens and causing cataract. The conjunctival cul-de-sac is disinfected with a warm saturated boric acid solution, and the length of the wound, and especially its angles, are inspected to see that the iris is not entangled. Should there be any entanglement of the iris, this must be carefully disengaged with the spatula or olive-pointed probe until the angles of the wound are entirely clear of iris tissue and the pillars of the coloboma perfectly in place. If the wound appears clear, the eye is dressed in the same manner as after cataract extraction (page 712). One or both eyes may be bandaged. The author prefers to bandage both of them for the first forty-eight hours. Usually the healing is kind, the anterior chamber is quickly restored, and the bandage may be removed at the end of forty-eight hours, and the patient directed to wear a shade or dark glass.

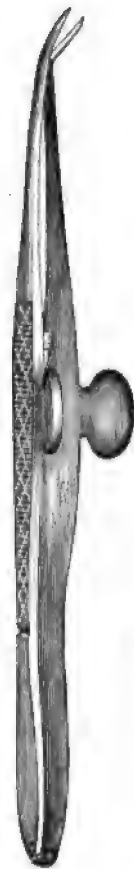


FIG. 232.—Iris scissors.



FIG. 231.—Blunt hook.



FIG. 233.—Spatula and probe.

This, in general terms, describes the method of performing an iridectomy, which, however, may require certain modifica-

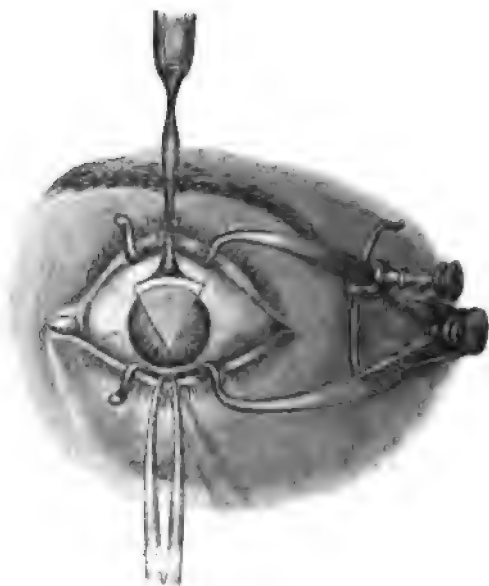


FIG. 234.—Operation of iridectomy; keratome within the anterior chamber.

tions according to the indications and according to the judgment of the operator.

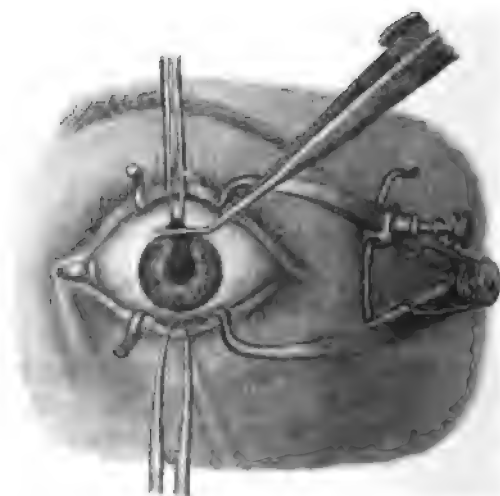


FIG. 235.—Operation of iridectomy; excision of the piece of iris.

1. *Position of the Operator.*—The operator may stand behind the patient's head and push the knife from him if he is making an upward section, or he may stand in front of the patient and push the knife toward him in a similarly made section. The latter procedure has been recommended if the anterior chamber is shallow, as the operator can more readily watch the point of the knife. This direction refers to the lance-shaped keratome. The author prefers to stand behind the patient's head.

2. *Point of Entrance of the Keratome.*—This depends upon whether the iridectomy is for optical purposes or for the relief of increased intra-ocular tension. If for the former, its position should be exactly at the apparent corneoscleral border; if for the latter, farther back, about 2 mm. from this position, passing through the sclera.

3. *Position of the Iridectomy.*—If the iridectomy is for optical purposes, the point of selection is governed by the condition of the cornea. The best position for an artificial pupil is inward or inward and downward, other things being equal.

If the operation is to restore a pupil to an iris which has been bound down by extensive synechiæ, that portion of the iris is excised which is least attached. Generally it is best to perform the section upward and make a broad iridectomy. The same is true if the operation is performed for a partial cataract, although its exact position must be governed by the condition of the lens.

4. *The Width and Depth of the Coloboma.*—A glance at the accompanying figures explains three forms of iridectomy—namely, a broad peripheral iridectomy, as in glaucoma; a small iridectomy, with preservation of the ciliary border; and a narrow iridectomy—for instance, for optical purposes.

**Iridotomy** (*Irotomy*).—This operation, which is designed to manufacture an artificial pupil, is commonly selected for cases in which the lens is absent, as after cataract extraction, and in which the pupil has become entirely occluded on account of iritis. It may be performed by simply splitting the fibers of the iris with a broad needle, the retraction usually affording a sufficient pupil; or a blunt hook (see Fig. 231) may be introduced and the operation converted into a small iridec-

tomy; or a triangular-shaped piece of the iris may be excised with delicate scissors introduced through a corneal wound. Ordinarily the method of de Wecker is the one which is employed. This is performed as follows:

A small triangular keratome, preferably fitted with a shoulder, is entered below into the apparent corneoscleral margin, if the iris is drawn upward, and pushed on until an incision of about 5 mm. is



FIG. 236.

FIG. 237.

FIG. 238.

FIGS. 236-238.—Fig. 236, broad peripheral iridectomy. Fig. 237, small iridectomy with ciliary border preserved. Fig. 238, narrow iridectomy for optical purposes (modified from Swanzy).

made. It is then slightly withdrawn and again reinserted, this time causing the point to pierce the iris or the membrane which it is desired to divide. The instrument is now withdrawn, and the delicate forceps scissors of de Wecker are introduced as follows: The instrument is inserted flatwise with closed blades through the wound. One blade is now made to pass through the opening in the iris or membrane and the other in front of it. The blades are now pushed onward as far as necessary, closed after the manner of a pair of scissors, and withdrawn. The cut thus being made across the line in



FIG. 239.—DeWecker's pince-ciseaux.

which there is the greatest tension, retraction takes place, and if the operation is successful, a useful pupil results. Sometimes, instead of a single cut, two cuts are made, slightly diverging from the entrance point in the iris or membrane, thus loosening a narrow, tongue-shaped portion, which afterward curls up toward its base.

Dr. Lewis S. Ziegler, of Philadelphia, for cases of membranous occlusion of the pupil following cataract extraction

makes a V-shaped iridotomy, or capsulotomy with a Hays knife-needle.

**Iridocystectomy**, designed by Dr. Knapp, is performed by this surgeon as follows :

A Beer's knife is made to pierce the cornea 3 or 4 mm. above the lower corneal border, opposite the scar from extraction, and to transfix the iris or pseudopupillary membrane by an opening 3 or 4 mm. long. The knife is now withdrawn, and with a blunt hook the lower lip of the incision in the iris or membrane is seized, drawn out of the wound of entrance, and abscised close to the cornea. The subsequent treatment is the same as that which is suited to iridectomy. This operation the author has practised with satisfaction.

**Division of Anterior Synechiæ** (*W. Lang's Operation*).—This operation is performed with a pair of knives closely resembling Knapp's dissection knife-needle. The one is sharp- and the other blunt-pointed. First, the sharp-pointed instrument is entered through the corneal tissue at a point favorably located for giving a fair lateral movement. It is then withdrawn, and the blunt-pointed knife passed through the same opening across the anterior chamber, with its cutting-edge in contact with the synechiæ. Then by a slight sweeping movement these are divided. Occasionally the iris stretches so freely that it is difficult to sever it. Practically no reaction follows the operation, and the subsequent treatment consists in the use of atropin and a compress bandage. If it has been successful, the iris may be dilated and the distorted pupil become round.

This operation, according to Lang, is suited to adhesion of the iris or capsule to the wound after cataract extraction, to traumatic prolapses where a broad width of iris is clamped in the scar, to small adhesions due to perforating wounds or ulcers, and, finally, to large adherent leukomas. In the last group the effects are the least satisfactory.

#### OPERATIONS UPON THE SCLERA.

**Sclerotomy** (*Anterior Sclerotomy*).—This is an operation first performed by Quaglino, and improved and advocated by de Wecker, which is practised for the relief of glaucoma, and in the hands of some surgeons is made to substitute the operation of iridectomy (see page 426). It is especially recommended in glaucoma simplex with deep anterior chamber, in inflammatory glaucoma with atrophy of the iris, and when iridectomy fails to reduce tension or to relieve the pain of old, blind glaucomatous eyes. It is performed as follows :

A narrow Graefe's cataract knife, or a specially constructed knife known as a *sclerotome*, is passed through the sclerotic, 1 mm. from the margin of the clear cornea in front of the iris, and brought out at a corresponding point on the other side—*i. e.*, the puncture and counterpuncture are placed as if the surgeon intended to form a flap 2 to 2.5 mm. in height out of the upper (or lower) part of the cornea. The puncture and counterpuncture are enlarged with a slight sawing movement of the knife, which is slowly withdrawn before the section is complete, leaving the central quarter of the sclerotic



FIG. 240.—Lines of incision in sclerotomy.

flap, and as much of the conjunctiva as possible, except where punctured, undivided. Thus, at the upper (or lower) margin of the cornea there remains a bridge formed of sclera which connects the parts below it. If prolapse of the iris occurs, replacement should be attempted with a horn spatula. In the event of failure the prolapsed iris must be excised and the sclerotomy converted into an iridectomy. Preceding the operation, eserine should be used to contract the pupil, and this drug must be continued during the process of healing.

**Posterior Sclerotomy.**—This is performed by entering a Graefe cataract knife at a point between the external and inferior recti muscles, 8 mm. from the corneal margin, and passing the blade through the sclera toward the center of the eyeball to a depth of 4 to 6 mm. As the knife is slowly withdrawn it is made to execute a quarter turn, the effect being the formation of a slight triangular wound, which, according to Parinaud, favors filtration. This operation is employed in hemorrhagic glaucoma, preliminary to iridectomy (see page 423), especially when the anterior chamber is very shallow, and in retinal detachment (see page 494).

**Internal sclerotomy** is practised by de Wecker and by de Vincentis under the name of incision of the tissue of the angle of the iris. The incision is similar to anterior sclerotomy, with omission of the counterpuncture, in place of which the arches of the pectinate ligament are incised.

**Enucleation of the Eyeball.**—The following instruments are necessary: A stop speculum, fixation forceps, dissecting forceps, strabismus hook, and a pair of scissors curved on the flat (enucleation scissors).

The patient being fully etherized, the lids are held apart with a stop speculum while the surgeon divides the conjunctiva and adjacent

fascia with scissors in a circle as close as possible to the margin of the cornea. This is sometimes called "circumcising the cornea." The tendons of the ocular muscles, beginning with the superior rectus, are then successively raised upon a strabismus hook and divided. The eye being made to start forward by inserting the stop speculum somewhat more deeply, the eye is drawn forward, the face of the patient being turned toward the operator, and the curved scissors are introduced between the severed conjunctiva and the freed eyeball, and made to follow the curve of the latter until the optic nerve is reached, when the blades are expanded and the nerve seized and cut squarely off. The attachments of the oblique muscles and the remaining tissue which may cling to the eyeball are then severed. Subsequently the conjunctival wound is closed with a few interrupted sutures.

Hemorrhage is usually not severe, and is readily controlled by pressure. After freely irrigating the socket with a bichlorid solution, it may be dusted with iodoform and a full antiseptic dressing should be applied.

The operation just described is sometimes known as Bonnet's method. The eye may also be removed by what is known as the Vienna method, as follows:

The only instruments necessary are a pair of strong scissors and toothed forceps. The tendon of the internal rectus, together with the overlying conjunctiva, is seized in one grasp with the forceps. It is then divided and the stump retained in the grasp of the instrument. With the scissors the inferior rectus and superior rectus are now divided, together with the overlying conjunctiva. The globe is drawn forward, rotated outward, and the optic nerve divided. The operation is concluded by cutting the external rectus and the two oblique muscles close to the globe. This operation can be rapidly performed. It, however, does not always yield as good a stump as the more slowly performed procedure previously described.

The methods of enucleation just described were almost universally employed until recent years. The technic, however, has been materially improved, chiefly by the various methods of suturing the tendons to the conjunctival bed to prevent their retraction. Sucker sutures the severed ends of the recti muscles one to the other, after which the conjunctiva from above and below is brought over the muscle-stump and fastened with a continuous suture, which also attaches the conjunctival covering to the muscle-stump. H. Schmidt secures each rectus tendon with a catgut suture and makes a slit in the conjunctiva over each muscle, in which



then the divided conjunctiva is fastened. The conjunctiva is brought together with a continuous suture. Priestley Smith pinches up a narrow horizontal fold of the conjunctiva over the internal rectus, so as to include the subjacent connective tissue and muscle, and carries a black silk suture through these structures with a curved needle, the suture being tied firmly but not too tightly. In a similar manner the other straight muscles are attached, after which the enucleation is carried out in the usual manner and the conjunctival aperture closed with one or more vertical sutures. The author has operated in the following manner with satisfactory results :

The conjunctiva is divided as close as possible to the corneal margin ; each rectus tendon is next exposed and caught upon a hook, precisely as in the operation for strabismus, and is secured with a double-armed black silk suture, which is knotted upon it. The eyeball is now enucleated with the least possible disturbance of the relations between the conjunctiva and the underlying structures, and a small ball of sterilized gauze is inserted into the capsule of Tenon, precisely in the manner in which a Mules's sphere would be so placed in the operation of implantation. Each rectus tendon is now drawn forward to the edge of the cut conjunctiva, and securely fastened with the ends of the same suture which had originally secured the tendon and which have been left long ; that is to say, the tendon is brought forward somewhat as it would be in the operation of advancement. The wad of sterilized gauze, which has served its purpose of checking entirely the hemorrhage and keeping, for the time being, the cavity bulged out as it was when occupied by the globe, and therefore facilitating the advancement of the tendons, is now removed, and the edges of the conjunctiva and capsule of Tenon are united with interrupted vertical sutures. The usual dressing is applied, both eyes being bandaged for twenty-four hours.

The effect of these operations is to give a movement to the conjunctival bed very much greater than that which is secured after the ordinary enucleation.

**Accidents.**—(a) *Hemorrhage.*—Occasionally severe hemorrhage occurs during the enucleation of an eyeball, sometimes caused by an anomalous distribution of the vessels. If necessary, the orbit can be packed with antiseptic gauze. The tissues of the orbit may become very much infiltrated with blood and puff out in an alarming manner. The blood-clot, however, will gradually be absorbed, and usually no harm results.

(b) *Perforation of the Sclera*.—Sometimes, especially in a ball having very thin walls, the sclera is punctured in the endeavor to cut the optic nerve. This simply complicates the operation, because it is more difficult to remove a collapsed ball than one which is distended. Should the operator be so unfortunate as to cut through the sclera and leave a portion of it remaining behind, he must proceed to search for the fragment, which can be picked up with forceps, and cut it off, together with the nerve.

(c) *Consecutive or Secondary Hemorrhage*.—Occasionally a consecutive or secondary hemorrhage occurs after enucleation. The bandages should be removed, the lids separated, the blood-clot removed, the orbit irrigated with an antiseptic fluid, and, if pressure fails to stop the hemorrhage, a packing of antiseptic gauze should be inserted.

The *after-treatment* of an enucleation consists in placing the patient in bed, certainly for the first few days. No severe pain ought to follow an enucleation, and decided headache, elevation of temperature, and restlessness may indicate meningeal complication. In a certain number of instances meningitis has followed the operation, especially when it has been performed on an eye within which suppuration is taking place. Under modern methods of operating and with antiseptic precautions this accident is fortunately a rare one.

**Insertion of Artificial Eyes.**—An artificial eye may be inserted as early as the second or third week after an enucleation of the eye; indeed, some operators insert it at a much earlier date. For the first week or two the artificial eye should be smaller than that which is a perfect match for the opposite side. The eye may then be exchanged for one which in size is as nearly as possible a match for the fellow-eye. At first the eye may be worn for several hours at a time. Soon it can be worn all day, but it never should be allowed to remain in the socket during the night. It is not necessary to keep an artificial eye in water during the night. It should be washed with a little alcohol and water, and allowed to dry. The wearer of an artificial eye must be cautious that the enamel is always smooth.

In order to insert an artificial eye, the upper eyelid is seized between the fingers of the left hand and drawn gently down and out, and the larger end of the shell is inserted vertically beneath it, then brought to a horizontal direction, while at the same time the lower lid is pulled down, when the shell slips into place. In order to remove an artificial eye, the head of a large pin is inserted beneath its lower margin, the lower lid being at the same time depressed, while the eye is tipped upward and forward, when the pressure of the upper lid will force it out. Very soon patients become exceedingly expert in taking out and introducing artificial eyes, and do not require the aid of a pin in making the manipulation just described.

One of the chief objections to the shell-shaped prothesis, or artificial eye, is the fact that in its hollow undersurface tears and mucus may accumulate, while its thin edges may bruise the conjunctival bed. To obviate this difficulty the so-called "reformed artificial eye" has been introduced, largely through the efforts of Professor Snellen, which consists of a double-



FIG. 241.—Average artificial eye or shell.



FIG. 242.—Solid artificial eye.

walled shell, or sometimes of a solid eye, the smooth rounded contour of which neutralizes the objections to the thin edges of the old-fashioned shells. When an eye of this character is placed in the socket after a properly-performed enucleation with suture of the tendons, the movements are nearly as good as those which follow Mules's operation.

Instead of the operation of enucleation, certain substitutes have been proposed, the most important of which are:

**Evisceration of the Eyeball.**—This consists in an evacuation of the contents of the eye, the sclerotic being unmolested, and closure of the scleroconjunctival wound with sutures, thus forming a movable stump for the artificial eye.

The instruments required for the operation are a speculum,

fixation forceps, a narrow knife, a pair of scissors, and an evisceration spoon. It is performed as follows :

The speculum being introduced, the conjunctiva is loosened around the cornea ; the anterior chamber is transfixed with the knife on a level with the horizontal meridian, the lower portion of the cornea separated, the flap seized with forceps, and the remainder of the cornea cut away at the corneoscleral margin. With the evisceration scoop the contents of the globe are thoroughly evacuated, care being taken that nothing is left behind, especially none of the choroidal tissue. The cavity of the globe is thoroughly wiped out with sterilized cotton-wool, and all bleeding is stopped. The edges of the conjunctiva are united by means of a suture similar to the string which draws shut a tobacco-pouch—a suture sometimes called the "*tobacco-pouch suture*," or by interrupted sutures. These may include the conjunctiva alone, unless this is very much macerated, when it may be necessary to include the sclera. The author is accustomed to suture both the sclera and the conjunctiva.

Considerable pain may follow the operation, together with edema and swelling of the surrounding tissues. In order to avoid this, it has been recommended to introduce a horse-hair drain, and Prince has suggested wiping out the cavity with carbolic acid in order to allay the pain.

The chief indication for evisceration is panophthalmitis (see also page 392), although it may also meet the indications which are mentioned below in connection with Mules's operation. Evisceration is contraindicated by sympathetic inflammation or irritation, malignant disease, and much shrunken eyeballs. Although the stump after evisceration is primarily more voluminous than that which is secured after an enucleation, subsequent shrinking of this stump ultimately renders the cosmetic effect of the operation no better than that which is secured by a properly performed enucleation, while its inconveniences are much greater.

**Evisceration of the Eyeball, with Insertion of an Artificial Vitreous.—Mules's Operation.**—Mr. Mules has modified the operation of evisceration by the introduction of a glass ball into the cavity of the sclera. The operation is performed as follows :

After general anesthesia a stop speculum is introduced, and the conjunctiva dissected from the corneoscleral attachment in all directions to the equator of the ball without disturbing the muscles.

The cornea and 1 mm. of the scleral margin are removed in the manner described under evisceration. Next the contents of the globe are emptied by any convenient method, a small evisceration scoop being a satisfactory instrument. Great care must be taken to remove the entire contents, leaving a perfectly clean, white sclera. Hemorrhage is controlled by packing the scleral cavity with sterilized gauze, and by frequently irrigating it with a tepid solution of bichlorid of mercury, 1 : 5000. A glass or gold sphere of such size that it may be introduced within the scleral cup without difficulty is selected, its introduction being facilitated by slitting the sclera vertically for about 4 mm. at the upper and lower margins of the opening. The introduction of the glass sphere is further facilitated by the use of an instrument specially devised by Mr. Mules for this purpose. The concluding steps of the operation consist in stitching the sclera vertically, the conjunctiva horizontally, and applying a full antiseptic dressing. The greatest care should be exercised to secure absolute asepsis during the operation and at the subsequent dressings. The patient should be confined to bed for at least four or five days. Considerable reaction may follow, and marked chemosis of the conjunctiva. This may be controlled by the continuous application of cold, and probably be avoided by not removing the bandage for forty-eight or even seventy-two hours. Mr. Mules recommends that the sutures should be of catgut; the author prefers silk sutures.

The chief *indications* for this operation are ruptured or injured eyeballs, when the sclera is not too much lacerated, and when the accident is of recent date; staphyloma of the cornea and sclera, or complete leukoma; absolute glaucoma; buphthalmos; and non-traumatic iridocyclitis. The chief *contraindications* are suppuration of the eyeball; morbid growths; much shrunken eyeballs, the contents of which have undergone bony or calcareous change; sympathetic ophthalmitis, sympathetic irritation, and pathologic conditions of the eyeball which are likely to produce either of the last-named affections; extensive injuries of the eyeball, with much bruising and laceration of the sclera; dacryocystitis; and ocular conditions demanding enucleation or its equivalent in very old persons.

**Implantation of an Artificial Globe in Tenon's Capsule After Removal of the Eyeball (*Frost-Lang Operation*).**—The eyeball is enucleated in the ordinary manner, and, after all bleeding has been checked, a gold or glass sphere is inserted within Tenon's capsule. The capsule and conjunctiva are next sutured over the artificial

## Extirpation of the Whole Contents of the Orbit 697

globe with silk sutures, the tendons of the ocular muscles having previously been secured by one of the methods described under enucleation. The subsequent treatment is the same as that suited to Mules's operation.

Several modifications of this operation have been suggested—for example, by H. McI. Morton and C. A. Oliver. The former surgeon endeavors to suture the opposing recti muscles so that they shall maintain as nearly as possible the same relationship to the implanted ball which they did to the eye; the latter surgeon secures the lateral and vertical recti by long, continuous catgut sutures, and after enucleation and implantation, sutures the divided recti together, thus inclosing the sphere within the capsule.

Sponge-grafting into the orbit for the support of an artificial eye has been suggested by Claiborne and Belt, and Suker wraps the glass sphere in a layer of sponge before its implantation.

Dr. L. Webster Fox has devised an operation which consists of *implantation of a glass or gold ball into the orbit after remote enucleation of an eyeball*. It is performed as follows:

"If the operation is to be performed on the right orbit, the eyelids are separated by a speculum, the conjunctiva is grasped up and in above the inner canthus, and the tissues are well pulled out. Next, a Beer's knife, or curved keratome, is passed through the tissues somewhat obliquely and well down into the orbit, and an opening made large enough for the insertion of the globe behind the tissues. This opening may be enlarged with curved scissors to the desired size. When ready, a gold ball is inserted through the opening, which is closed with two stitches and over which a shell is placed, modeled after an artificial eye. The eyelids are then closed over this shell, which is left in place for twenty-four hours. The stitches are taken out on the third day. If the operation is to be performed on the left orbit, the incision is made up and out above the external rectus muscle and the dissection carried out as above described."

Opticociliary neurotomy and neurectomy have been employed as substitutes for enucleation, and are still performed by some surgeons, but in the opinion of the author they are rarely to be recommended.

## **Extirpation of the Whole Contents of the Orbit**

(*Exenteration*).—This is the operation necessary in certain cases of malignant disease.

The eyeball having been removed in the ordinary way, an incision is made through the outer commissure to the edge of the orbit. The lids having been widely separated, the tissues back of them and the periosteum within the orbital margin are divided with a scalpel. Next, the periosteum is separated to the apex of the orbital cavity, where the entire mass of tissue is detached with strong curved scissors or other suitable instrument. Bleeding, which is sometimes considerable, may be checked by pressure, or, if necessary, by the actual cautery. The cavity is packed with iodoform gauze and an ordinary antiseptic dressing applied, which should remain for several days. It may happen that the eyeball is so involved with the malignant disease which is present that its extirpation as the first step of the operation is not feasible. The operator then proceeds as before described, removing the eyeball with the entire mass of tissue.

**Removal of Tumors of the Orbit.**—In a certain number of instances tumors of the orbit can be removed without sacrificing the globe. If, for example, the tumor arises from the optic nerve, or, in other words, is within the cone of the muscles, it may be reached by an incision of the conjunctiva on the inner side of the eyeball, followed by detachment of the internal rectus tendon, which is secured by a silk ligature and held out of the way while the tissues are separated and the growth exposed, which is brought forward, isolated, and excised. Bleeding is arrested by pressure, the eyeball replaced, and the severed tendon and conjunctiva sutured into place.

When the tumor is outside of the cone of the muscles, it may be reached by an incision along the orbital margin, and gradually exposed by separating it from its surroundings with the handle of a scalpel or similar instrument. After removal, all bleeding must be carefully stopped; drainage is usually required, and the wound is closed with silk sutures.

Krönlein has devised an operation by means of which orbital tumors may be exposed and removed by a temporary resection of a wedge-shaped portion of the orbital wall. In general terms, the operation may be performed as follows; according to Arnold Knapp's description :

*Krönlein's Operation.*—A curved vertical incision is made along the outer bony margin of the orbit, dividing the periosteum. The

periosteal lining and the inner side of the lateral wall of the orbit are retracted together with the soft orbital contents, and the inferior orbital fissure localized. At the anterior end of this fissure the bony wall of the orbit is cut through with a chisel up and out to the external angular process of the frontal, practically in the suture between the great wing of the sphenoid and the malar bone, and outward and forward on the external surface of the malar bone in a line directly above the zygomatic arch. This wedge-shaped piece of bone with its muscular and cutaneous attachments is strongly forced backward, giving free access to the orbit. After removal of the tumor and checking of hemorrhage the osteoplastic flap is replaced and the wound closed with deep and superficial sutures.

#### OPERATIONS FOR CATARACT.

The following methods constitute the most important varieties of operation which are practised for the cure of cataract:

Extraction without iridectomy, so-called simple extraction; extraction with iridectomy, so-called combined extraction; linear extraction; the needle operation, or discission; and the suction method. The old operation of *reclination*, *depressing*, or *couching*, as it has been variously called, by which the lens was forcibly thrust down into the vitreous, is rarely practised at the present time, although recently some surgeons—for example, Mr. Henry Power—have suggested that the operation is advisable in patients greatly enfeebled by age or other infirmities, when chronic conjunctivitis or dacryocystitis fails to yield to treatment, in lunatics, imbeciles, and others whose actions cannot be controlled, and particularly if one eye has been lost by intra-ocular hemorrhage. Similar recommendations have been made in France.

##### **i. Needle Operation** (*Discission—Operation for Solution*).

—By this operation the capsule of the lens is opened, the aqueous humor admitted to the lens-matter, and absorption thus promoted. It is applicable to congenital and juvenile cataracts, and to some traumatic cataracts, and is rarely employed after the fifteenth year.

The instruments required are two cataract needles (lance-headed or knife-needle according, to the fancy of the operator), a stop speculum, and fixation forceps. The eye in this and all operations of similar character should be prepared in the manner described in page 705.



After the induction of general anesthesia in young children, or the use of cocain in older subjects, and full dilatation of the pupil, the operation is thus performed :

The lids being separated by the stop speculum, the surgeon fixes the eye with forceps, and enters the cataract needle through the cornea at its outer margin and carries it across to the center of the pupil, where the point is turned to the lens, the shaft caused to enter

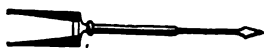


FIG. 243.—Bowman's stop needle.



FIG. 244.—Knife-needle.

the cornea a little more deeply, and a laceration made in the capsule by depressing the handle of the instrument with a lever-like movement. Two cuts are made at right angles with each other, and the lens-matter may then be slightly broken up with the point of the needle. Care must be taken not to use so much force as to dislocate the lens, and not to lacerate too freely in the first operation, lest the lens-substance, swelling up from contact with the aqueous humor, should produce injurious pressure on the iris and ciliary body. The operation usually has to be repeated at intervals,

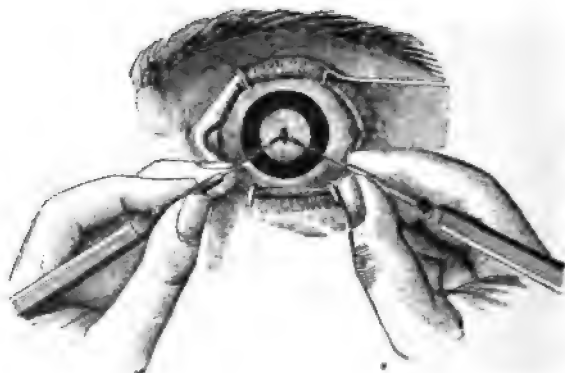


FIG. 245.—Discission with two needles.

the second operation being done after the swollen lens-matter caused by the first incision has disappeared by absorption and the eye has become perfectly quiet.

At the second operation the needle may be used more freely, or two needles may be used in the manner shown in the figure (Fig. 245). The points enter the lens-substance and the handles are approximated, thus making a decided separation in the remaining opaque matter. The use of two needles is applicable to cases where not much lens-tissue remains. In order to prevent too deep

entrance of the needle it is sometimes constructed with a shoulder (stop needle ; see Fig. 243).

**After-treatment.**—The conjunctival sac should be irrigated with boric acid or physiologic salt solution, atropin freely instilled, and pupillary dilatation maintained during the entire treatment. Cold compresses are recommended by some surgeons for the first twenty-four hours. Both eyes should be lightly bandaged.

Decided reaction, with hyperemia of the iris, pain, and ciliary congestion, indicates a more frequent use of atropin, and if the age of the patient permits it, the use of leeches to the temple. Great swelling of the lens-matter, in addition to the symptoms of iritis, may give rise to a glaucomatous state. Then the lens-matter which has escaped into the anterior chamber must be evacuated by a *linear extraction*, or, what is practically the same thing, by a free paracentesis of the cornea. The *suction method* may also be employed under these circumstances. Some operators invariably extract the lens a few days after needling—a practice which certainly hastens the restoration of vision, but which is not so safe as repeated discissions. The student should remember that even in the hands of the most skilful surgeons the operation of needling a cataract is surrounded with dangers, and sometimes has resulted in a general inflammation of the globe and loss of the eye—dangers which are lessened by strict asepsis, proper laceration of the capsule, and care not to undertake too much at the first operation.

**2. The Suction Method.**—This operation is specially adapted to cases of completely soft or fluid cataracts, and is also used, as has been stated, to remove lens-matter which has been broken up by discission. It is done as follows :

The pupil being dilated with atropin, the anterior capsule of the lens is freely lacerated with two needles. A small wound is made with a keratome passed obliquely through the cornea between its center and periphery. Through this opening and into the lens-matter the "suction curet" is passed. This consists of a curet roofed in to within 2 mm. of its extremity, with a handle and a piece of India-rubber tubing furnished with a mouth-piece, which the operator applies to his lips and gently sucks out the lens-matter into the syringe. This is Teale's method.

The same may be accomplished by using the syringe of Bowman, in which a sliding piston is worked by the hand. The point of the syringe must not penetrate too deeply, must be behind the lens-matter which is to be removed, and must not be pushed back of the iris.

The after-treatment consists of rest, bandage, and the local use of atropin.

**3. Linear Extraction.**—This operation is designed for the removal of soft cataracts or those with a very small nucleus, and may be employed to remove lens-matter after discission. Although any lens, the substance of which is liquid enough to pass through a small corneal wound, may be removed by this method, it is better, if possible, to restrict the operation to cases of soft cataract occurring in patients under thirty years of age.

The following instruments are necessary: A narrow keratome or lance-shaped knife, fixation forceps, cystotome, curet, and stop speculum. The operation is as follows:

The surgeon fixes the eye with forceps, after the introduction of the stop speculum, wide dilatation of the pupil having previously been obtained, introduces the keratome about 1 mm. within the margin of the cornea, and makes a wound 5 mm. wide. The instrument is now carefully withdrawn, with a slight lateral motion to make the wound a little larger if necessary, and a sharp cystotome is introduced and the capsule of the lens is freely lacerated. The soft lens-matter is now caused to extrude by counterpressure on the cornea with a metal spud, the outer lip of the corneal wound at the same time being depressed with a curet. This is a *simple linear extraction*.

The same manipulations may be performed, assisted by an iridectomy after the corneal section, a small segment of the iris being withdrawn with either hook or forceps and excised. Instead of using the cystotome to open the capsule of the lens, some operators do this with the keratome after making the incision in the cornea by causing the instrument to dip directly into the lens.

The after-treatment consists of bandage, atropin, and rest in bed until the eye is quiet.

**4. Extraction of Hard Cataract.**—It would be impracticable to indicate the numerous modifications which have been employed in this operation, than which, as Dr. Noyes says, no surgical procedure has been more carefully studied

and elaborated in every detail. Hence only those methods which the author is accustomed to employ will be described.

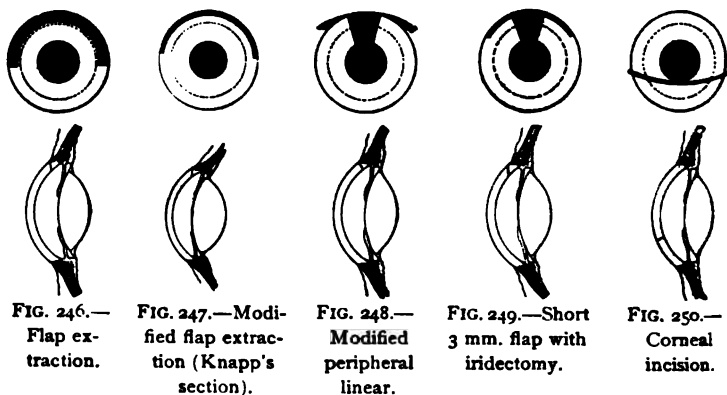
(a) **Extraction without iridectomy**, often called *simple extraction*. This method of operating is much employed at the present time—in fact, in a certain sense it is a return to the old-fashioned flap extraction in vogue many years ago, although the method has been materially modified. The author is accustomed, following Dr. Knapp, to proceed as follows: The corneal section for full-sized cataracts comprises exactly the upper half of the cornea; for smaller, Morgagnian, and soft cataracts somewhat less. A perfect section passes in its whole extent exactly through the transparent margin of the cornea, the knife (Fig. 255) remaining in the same plane throughout, particular care being taken that in completing the section the blade of the knife is not turned forward nor backward. In many cases a small central conjunctival flap is formed, which, if anything, is an advantage. (For steps of operation see pages 707-712.)

(b) **Extraction with iridectomy**, often called *combined extraction*. The peripheral linear extraction of von Graefe, by means of which the extreme periphery of the anterior chamber was opened by an incision 10 mm. long, through the sclerotic, 1 mm. external to the margin of the cornea and 2 mm. below the tangent of its summit, has been abandoned by almost all operators owing to its dangers—hemorrhage from the conjunctiva, loss of vitreous favored by the peripheral position of the wound, and cyclitis and consequently danger of sympathetic involvement of the other eye, and in its place one or other of the various so-called short flap operations is performed.

A useful method is the following: A Graefe cataract knife is entered exactly at the corneoscleral junction at the outer extremity of a horizontal line which would pass 3 or 4 mm., according to the size of the cataract, below the summit of the cornea. Counterpuncture is made at a similar point directly opposite, and a flap is cut which embraces one-fourth or one-third of the cornea. A small conjunctival flap may be made or not. Iridectomy is performed. (For steps of operation see pages 707-712.)

With the various *corneal incisions* which have from time to time been practised for the removal of cataract the author has no experience. Liebreich made an incision in the form of a curved section through the lower portion of the cornea, puncture and counterpuncture being effected in the sclerotic, while Lebrun caused the corneal flap to occupy the upper portion of the cornea and to be 3 mm. high, puncture and counterpuncture being made 2 mm. below the extremities of the transverse diameter of the cornea. In these operations iridectomy was usually omitted.

(c) **Extraction without capsulotomy** is performed by some surgeons—that is to say, the lens is delivered without open-



ing the capsule. The operation finds its chief indications in cases of overripe cataract and of high myopia with vitreous changes. Pagenstecher under these circumstances makes his section in the lower half of the cornea by an incision placed in the sclerotic, 1 mm. from the corneal edge. Iridectomy is performed and the lens is delivered in its capsule with the loupe or a specially devised curet. The chief danger of the operation is the risk of extensive loss of vitreous. The visual results are very good in successful cases. In the few cases in which the author has performed this operation he has delivered the lens with a loupe after iridectomy through a section made in the corneoscleral junction.

By an examination of the accompanying diagrams the posi-

tion of the incisions in the various methods just detailed may be understood.

**Preparation of the Patient and the Eye.**—This should include a thorough examination of the physical condition of the patient; the removal of the conditions, already named (page 445), which contraindicate the operation; and surgically clean surroundings.

For some days previous to the operation, as Knapp insists, the eye should be protected from anything which may produce congestion, and the patient should remain in the hospital, perfectly resting his eye and body, and frequently washing his face and the surface and margin of the eyelids with soap and water. This simple regimen will frequently change a congested and irritated conjunctiva into a pale and shining membrane. During these days scrupulous attention should be given to the nasopharynx. In recent years the author, following a suggestion of J. A. Lippincott, of Pittsburg, has been accustomed to spray the nasopharynx three times daily with a solution of permanganate of potassium, 1 : 5000, with gratifying results.

The preparation of the skin of the region of operation, and particularly the ciliary margins, has been described on page 652. These preparations should be made at least two hours before the operation, and the eyes should then be covered with squares of lint soaked in a solution of bichlorid of mercury 1 : 5000, held in place with a gauze roller. Just preceding the operation, the preparatory bandage having been removed, the ciliary margins may again be washed with soap and water, followed by bichlorid of mercury, 1 : 5000, with the same precautions previously described. Next, the conjunctival cul-de-sac should be flushed with a tepid solution of boric acid applied with some force, or with a sterile physiologic salt solution. During these irrigations pressure should be made over the lacrimal sac in order to be sure that no deleterious secretion is contained within it. The lids are then everted, the tarsal conjunctiva and the region of the inner canthus wiped with a pledget of cotton moistened in the boric acid solution. The cornea should be anesthetized with three

instillations of a sterile 4 per cent. solution of cocain, applied at intervals of five minutes, and the eye carefully closed and covered with the antiseptic pad after each instillation. In place of cocain some surgeons prefer holocain in 2 per cent. solution. Just before the knife is entered the surface of the cornea should be carefully wiped with a pledget of cotton soaked in boric acid solution. This same method of preparing an eye should be practised not only in cataract extraction and discission, but also prior to all operations requiring corneal incision—for example, iridectomy, etc.

**Position of the Patient.**—The patient during the operation should lie, according to the custom of



FIG. 251.—  
Lid-elevator.



FIG. 252.—  
Metal spoon.



FIG. 253.—  
Wire loop.



FIG. 254.—  
Cystotome.



FIG. 255.—  
Cataract  
knife.

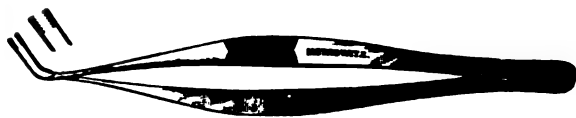


FIG. 256.—Capsule forceps.

the operator, upon an operating chair suitably inclined or upon a bed. If the latter, the head should rest on a moderately hard cushion or pillow, covered with a sterile sheet, another pillow at the same time supporting the shoulders, so that the position is as little strained as possible. The face must be turned so that a uniform light falls upon it.

**Instruments, Solutions, and Dressings.**—The instruments required are the following: A stop speculum, a lid-elevator, a spatula, a wire loop, a spoon, an olive-tipped probe, a curet, a cystotome, capsule forceps, a pair of scissors, iris forceps, iris scissors, and the cataract knife.

The following lotions and dressings should be at hand: Atropin drops (4 grains to the ounce), eserine drops ( $\frac{1}{2}$  grain to the ounce), cocain solution (4 per cent.), saturated solution of boric acid, two solutions of bichlorid of mercury (1 : 5000 and 1 : 10,000), and boiled distilled water containing 0.5 per cent. of chlorid of sodium. Suitable bulb syringes are to be provided.

For the purpose of dressings the following may be needed: Several rollers, two inches wide and five yards long, made of sterilized gauze, two or three flannel rollers of the same size as the antiseptic bandage; and sterilized oval pads of lint and absorbent cotton.

Everything being in readiness, the operation may be performed as follows:

The surgeon, if he is ambidextrous, may stand behind the patient, no matter which eye is to be operated upon; if he is not, he should take this position for the right eye only, standing at the patient's side and in front for an operation on the left eye. Again, if the surgeon is ambidextrous, he may stand in front and at the patient's right side for an operation upon the right eye, and at the patient's left side and in front for an operation on the left eye.

The speculum having been inserted, the surgeon steadies the eyeball and draws it downward with the fixation forceps (it is supposed that the section is being made upward), by taking firm hold of a fold of conjunctiva below the inferior border of the cornea, enters a Graefe cataract knife exactly at the corneoscleral junction, as before described, at the outer extremity of a horizontal line which would pass 3 or 4 mm., according to the size of the cataract, below the summit of the cornea, passes across the anterior chamber to a corresponding point upon the opposite side, and makes the counter-puncture. The knife is pushed steadily onward as far as possible, with an upward tendency, and the incision is completed by a free cutting, not a sawing or dragging movement, keeping the knife in the same plane throughout, and not turning its edge at the completion of the section either forward or backward. This manœuvre will create a small conjunctival flap. If this is not desired, when the summit of the cornea is reached the knife must be turned a little



forward before the completion of the flap. This completes the *first stage* (Fig. 257).

In the *second stage*, or the stage of iridectomy, the fixation forceps are intrusted to the assistant (trained to hand the instruments in their proper order), who gently draws the eyeball downward, while the operator takes in his left hand the iris forceps and in his right hand the iris scissors. If the iris is already protruding in the wound, a small portion of it may be seized and snipped off with a single cut close to the border of the cornea. If not, the blades of the instrument must be introduced in the manner described under iridectomy, and the pupillary border of the iris seized, the tissue drawn out and toward the cornea, and cut off with two snips of the scissors close to the cornea. It is not necessary to make a large coloboma. If the patient is to be trusted, it is not necessary that the assistant shall

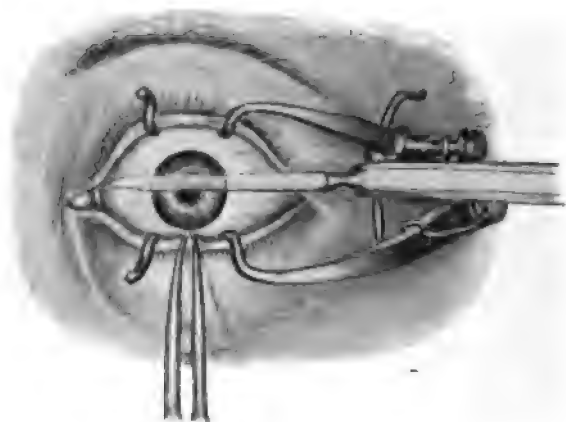


FIG. 257.—The incision in cataract extraction. Puncture and counterpuncture have been made. The section will pass in its whole extent exactly through the transparent margin of the cornea, the knife remaining in the same plane throughout.

draw the eyeball downward while iridectomy is being performed. The patient may simply be directed to look downward while the surgeon proceeds to remove a small portion of the iris in the manner already described. The pillars of the coloboma should now be carefully smoothed out with a delicate spatula. This completes the *second stage* (see Fig. 235).

In the *third stage*, or the stage of capsulotomy, the operator takes in one hand the fixation forceps and gently steadies the eyeball, while with the other he introduces the cystotome, held flatwise during its insertion, passes it to the bottom of the coloboma, and then turns its cutting-edge toward the capsule. From this point a vertical incision is traced until the upper portion of the coloboma is reached, where a transverse cut is made. Great care should be taken to cut, and not to tear, and the whole manœuvre should be accomplished

without undue pressure lest the lens be dislocated. Other methods of opening the capsule are the following: Two cuts inclined to each other are made like the limbs of the inverted letter V, together with a transverse cut at the periphery; or, as recommended by Knapp, the capsule may be opened in its extreme periphery, with the understanding that later on the necessity for the operation for after-cataract will arise. Some surgeons open the capsule with capsule forceps, as a rule; the author prefers to use this instrument only in cases in which the anterior surface of the capsule is thickened. In withdrawing the cystotome the operator should again turn it flatwise, and be careful not to drag any tags of capsule into the wound. This completes the *third stage*.

In the *fourth stage*, or that of delivery of the cataract, the operator draws the eye slightly downward, or, if he has a docile patient, causes him to look downward, while the assistant raises the specu-

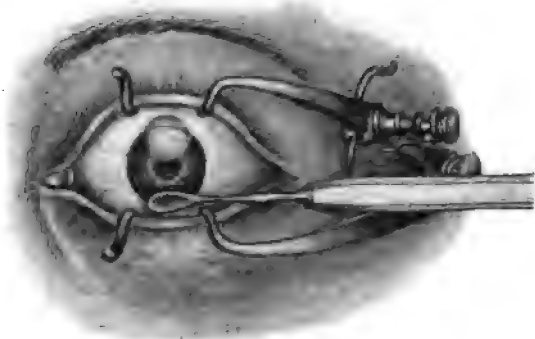


FIG. 258.—The delivery of the lens; the lens is presenting in the wound (capsulotomy has been performed).

lum so that its blades shall not press upon the eyeball and yet shall hold the lids away from the eye. The back of a curet or the convex surface of the metal spoon is now laid against the inferior portion of the cornea, and firm but at the same time gentle pressure is made, causing the upper margin of the lens to appear in the wound. The pressure is now exercised with an upward motion to coax out the cataract, but is relaxed as soon as the major portion has been expelled, in order that no undue tension be put upon the zonula. As the cataract slips through the wound the spoon is made to follow it and catch it, when it is lifted out with a little sweeping motion which may at the same time remove any small fragments of the cortex which have broken off and lie at the margins of the incision. The speculum is then removed. This completes the *fourth stage* (Fig. 258).

In the *fifth stage*, or that which is now called the "toilet of the

wound," after the eye has been allowed to remain closed for a few moments the operator cautiously inspects the wound, after raising the upper lid with his fingers, or preferably with a lid-elevator, while the patient looks downward. In this inspection he should ascertain whether the pupil is clear or whether any cortical remnants are present or tags of capsule lie between the lips of the incision. If cortical matter remains, it should be removed as follows: The eye being turned downward, the operator makes a gentle rubbing movement in an upward direction on the cornea with the lower lid, or, better, for fear this may transmit some infection, with the convex surface of a horn spoon, great care being taken not to press too hard lest vitreous escape. By rubbing gently in a circular manner the cortical particles will gather in the upper part of the wound, and then, while the slight pressure continues, the lips of the wound may be gently separated with the metal spatula and the expulsion of the cortical remnants effected. Blood-clot, the result of hemorrhage from the iris, may be expelled in like manner. While these manipulations are being made, the author is accustomed to flood the surface of the eye and lips of the wound with a physiologic salt solution. After they are completed, a final inspection is made, and in order to be sure that no tag of capsule remains in the wound, or that no portion of the conjunctival flap has been caught between its lips, the olive-pointed probe is gently passed from one end of the incision to the other.

Some surgeons have advocated the procedure which is known as *irrigation of the anterior chamber*, which, as has already been stated, is used also in the operation of unripe cataract. In this maneuver the tip of a specially devised syringe is introduced between the lips of the wound, and the irrigating liquid injected, which then causes blood-clot or cortical matter to be washed out. If irrigation is employed, two cautions are necessary: (a) No strong antiseptic solution should be used, certainly never bichlorid of mercury, which is liable to produce indelible staining of the cornea. If any liquid which deserves the name of an antiseptic is employed, boric acid may be tried, but even this is better replaced by boiled distilled water containing 0.5 per cent. of the chlorid of sodium. (b) In passing the liquid from the syringe into the anterior chamber the direction of the flow should be over the wound from within outward, and not the reverse, lest particles of blood and cortex be driven inward. This caution Dr. Knapp especially dwells upon. The author is not in favor of anterior chamber irrigations.

A general inspection of the conjunctival sac may now be made; sometimes a little blood-clot or a cilium may be present. In wiping away any clots, delicate pieces of sterilized gauze are very suitable, or the clots may be picked up with the iris forceps. If all these manipulations have been successfully performed, the conjunctival cul-de-sac will be free from foreign matters, the edges of the wound nicely coapted, the pillars of the coloboma as straight as possible, and the angles not caught in the margins of the wound, the pupil

black, and the patient readily able to count fingers. This completes the *fifth stage*.

If the operator intends to perform *extraction without iridectomy*, the following additional directions will be found useful. As the author is accustomed to perform the operation according to Knapp's rules, the advice of this surgeon is quoted:

After performing the section according to the method already given (see page 703, also Fig. 247), the expulsion of the lens is effected by pressing the lower part of the cornea with a Daviel's spoon directly toward the center of the globe. When the lens presents in the gaping section, its exit is aided by slight strokes with the spoon on the outer surface of the cornea. If the sphincter proves to be rigid, it may be drawn backward with a wire loop or with a special iris retractor, and usually it is safer to remove both fixation forceps and speculum immediately after the corneal section and during the process of expelling the lens, or the speculum may be raised in the manner already described. If desirable, the upper lid may be elevated under these circumstances with a sterile strabismus hook in the ingenious manner advocated by Dr. Noyes, or with a lid-elevator. The pupillary space should be cleared by pressing on the cornea with the edge of the lower lid—care being taken that it does not come in contact with the lips of the wound—or, better, with the convex surface of a polished spoon. The cortical remnants are wiped away with a probe-pointed curet. During this operation the lips of the wound may be flooded with the boric acid or sterilized salt solution (Knapp uses a 1 : 10,000 solution of corrosive sublimate).

The concluding steps of the operation are described in Knapp's own words: "The conjunctival flap, if there may be any, is smoothed out by introducing the end of a polished grooved spatula, previously sterilized, into the anterior chamber, and passing it through the wound from one end to the other, stroking from within outward, in order to remove particles of lens, redress a curved-in flap, and carefully adjust the edges of the wound. This is, however, not done before the iris has spontaneously or artificially recovered its natural position. Should the corneal section be too peripheric, the best thing is to make a small iridectomy at once, for peripheric (Graefe's) sections commonly lead to large and harmful prolapses.

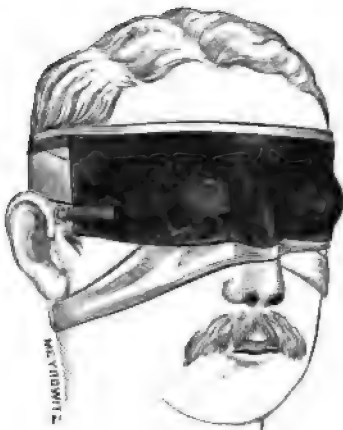


FIG. 259.—Ring's ocular mask.

If the iris does not spontaneously resume its position, frequently it does so when the lower part of the cornea is pressed upon with the edge of the lid. This paradoxical phenomenon may thus be explained: The iris being pinched in the tightly closing wound, pressure on the part of the cornea raises the flap and disengages the iris, which then, by its natural elasticity and contraction of the sphincter pupillæ, can resume its natural position. If this procedure fails, the iris should be pushed back with a spatula into the anterior chamber. When the periphery of the iris remains folded in the sinus of the anterior chamber, it is smoothed out with the olive-tipped point of a probe introduced into the iris angle behind the opaque corneal margin."

The final stage of all cataract operations is the application of the dressing. Much difference of opinion exists upon this subject. Some operators simply close the lids with a strip of isinglass plaster, while others place upon them an elaborate bandage.

The author is accustomed to use the following dressing: An oval piece of soft lint soaked in a solution of bichlorid of mercury, 1 : 5000, is laid upon each closed lid; over this is placed a similarly shaped piece of sterilized cotton, large enough to be flush with the eyebrow and lower margin of the orbit, and is held in place with three narrow strips of surgeon's isinglass plaster, passed from the inferior edge of the orbit to a point above the brow. The entire dressing is covered with the mask devised by Dr. Frank Ring, of New York (Fig. 259). The patient is then put to bed in a comfortable position in a slightly darkened room, although with the aid of the mask the latter precaution is unnecessary, and the case may remain in the open ward of the hospital or in an ordinary room without danger.

**After-treatment.**—For the first few hours, the effects of the cocain having passed away, there are some smarting and burning, but severe pain should not occur. If at the end of twenty-four hours after a combined extraction there has been no discomfort, no headache, and nothing to indicate that any anomaly in the course of healing is going on, the bandages need not be removed; but if they have become disarranged or the patient has been uncomfortable, they should be taken off and the lids inspected. A little staining of the strip of lint is of no consequence, and if the eyelids are not swollen and there is no discharge, and the delicate veins in the skin of the lids show no distention, the eyelids need not be opened, and the dressing may be reapplied; or the lower lid may be gently drawn downward so as to permit the escape of tears which may have accumulated in the conjunctival cul-de-sac, or to

liberate the eyelashes if they have become inverted. At the end of forty-eight or seventy-two hours the wound may be inspected by candle-light, a drop of sterile atropin solution instilled, and each succeeding day the usual dressing reapplied; at the end of three days the dressing may be removed from the unoperated eye, and at the end of a week the patient needs only a shade and dark glasses. Although some operators do not require cataract patients to go to bed at all, it seems to the author that it is safer to keep them in bed for three or four days. The recumbent posture too long maintained may lead to hypostatic congestion of the lungs. Sometimes old people are very uncomfortable when confined to bed, and become slightly delirious; under these circumstances they may be allowed to rest in an easy-chair. For a few days liquid food, or at least food which does not require much chewing, should be given; after this the ordinary diet suited to the patient is permissible.

If the operation has been an extraction without iridectomy, it is proper to inspect the eye at the first dressing, usually at the end of twenty-four hours, in order to ascertain whether there has been any prolapse of the iris. Should this accident have occurred, the treatment must be pursued according to the directions given elsewhere. If the iris is in place and the pupil circular, although it is proper to change the dressings once in twenty-four hours, it is unnecessary to inspect the line of incision. All that is required is to draw down the lower lid and permit the escape of any accumulated tears. If the wound is closed on the third day, a drop of a sterile atropin solution may be instilled and this instillation repeated at subsequent dressings.

**Accidents.**—The following accidents may occur during the performance of a cataract extraction :

1. The knife may be introduced with the cutting-edge turned in the wrong direction. If this somewhat inexcusable mistake should occur, the knife must be withdrawn and properly inserted. If this cannot be done, owing to the escape of the aqueous, postponement of the operation until the anterior chamber has refilled is necessary.

2. The conjunctiva in the neighborhood of the counter-puncture may become distended with aqueous humor. This produces an elevation resembling a bleb. The section should be completed as if the accident had not happened.

3. The iris may fall before the knife. The incision should be completed in the ordinary way. An irregular coloboma will result, which may be remedied by seizing the jagged edges with the iris forceps and trimming them with the scissors.

4. Free hemorrhage may occur if a conjunctival flap is made or in performing the iridectomy. Under pressure the bleeding will sometimes cease, and the operator should then endeavor to get rid of the blood in the manner already described. If success does not follow the maneuver, the cystotome must be introduced, even though everything is obscured by the blood, the capsule lacerated, and the lens expelled. During its expulsion sufficient blood will often come away to clear the pupillary space.

5. The wound may be too small. This is a very unfortunate occurrence, and can be remedied only by enlarging the incision, which is best done with a small pair of probe-pointed scissors.

6. Undue pressure of the cystotome may cause the lens to be partially or completely dislocated. If the dislocation is partial, the eyes should be closed and gentle pressure should be made with a bandage, when the lens probably will right itself and can be delivered. If the dislocation is complete and the lens slips back into the vitreous, it must be removed by means of the scoop or wire loop.

7. The vitreous may escape before or after the expulsion of the lens. If before the expulsion of the lens, the operator should at once remove the cataract with the wire loop, which is gently inserted behind the lens. At the same time all pressure upon the eye must be removed. If vitreous escapes after the lens has been extracted, the wound should be cleared of protruding vitreous as gently and rapidly as possible and a bandage applied. Although escape of vitreous is an undesirable accident, its consequences are not always serious and good

visual results may be obtained. If the escape of vitreous has been great, particularly if the vitreous is thin and there is tendency for the eyeball to collapse, a tepid sterile physiologic salt solution should be injected into the vitreous chamber until the globe assumes its proper contour, as has been recommended by J. A. Andrews and Herman Knapp.

8. Occasionally the corneal flap is everted because it has been caught by the margin of the lid, owing to a sudden movement of the patient. It must be replaced and a bandage quickly applied. Sometimes immediately at the conclusion of the section, or directly after the delivery of the lens, especially in old and feeble subjects, there is great collapse of the cornea, which, instead of keeping its proper curve, looks like a wrinkled membrane. Under these circumstances the anterior chamber should be filled with physiologic salt solution, which will not only aid in making proper coaptation of the lips of the wound, but will prevent the sucking in of the conjunctival juices which might lead to infection.

9. Capsulotomy may not have been sufficient and pressure upon the inferior half of the cornea fails to cause the lens to present. In such a case the cystotome must be reintroduced and the laceration enlarged, or if the obstruction is due to the presence of a tenacious center in the capsule, this may be excised with capsule forceps.

**Anomalies in the Healing Process.—Pain.**—Should pain occur and not be due to the circumstances already mentioned, but become violent in character, either in the earlier stages after the operation or some days afterward, one of three things may be apprehended: intra-ocular hemorrhage, suppuration of the wound, or iritis.

**Intra-ocular Hemorrhage.**—This is a most distressing accident, and presages loss of the eye. Usually, soon after the operation has been completed, the patient complains of very severe pain, or vomiting may occur and the dressings begin to be stained with blood. On removal of the bandage a clot of blood will be found protruding through the palpebral fissure, and on raising the lid the anterior chamber is seen to be full of blood and the corneal wound gaping widely. As soon as



the symptoms of this accident are manifest, the patient should be placed in an upright position and a hypodermic injection of morphin administered, and, as Knapp advises, the blood should be carefully removed, the conjunctival sac washed out with a weak bichlorid solution, the outside of the lid sterilized, and a full antiseptic dressing applied. The dressings should be changed once or twice daily. In this way it may be possible to avert suppuration, even though the eye remains blind. If the hemorrhage should continue and the pain become intense, enucleation is necessary.

*Suppuration of the Wound.*—Great care in antiseptic details has rendered this accident rare at the present time. According to Collins, it is more common in old people than in young, and the tendency is greater between sixty and seventy than between seventy and eighty, though it is certainly greater between eighty and ninety than between sixty and seventy. Suppuration has no relation to the time of year at which the operation is performed. It may be caused by lacrimal complication, inflammation of the upper respiratory tracts, conjunctivitis and blepharitis, by infection introduced at the time of the operation, and finally by want of sufficient nutrition in the cornea. Suppuration commences on the first, second, or third day, more rarely on or after the fifth day, but sometimes as late as the thirteenth day.

The symptoms are pain, swelling of the lids, chemosis of the conjunctiva with undue secretion, haziness of the cornea, turbidity of the aqueous, and the formation of a slough along the margins of the wound.

Two terminations are possible: The suppurative process may be limited, so that at the end of the inflammation the pupil is closed and the iris drawn upward, or the entire globe may participate in a general destructive inflammation (purulent panophthalmitis).

If the suppuration is limited to the margin of the wound, prompt treatment may be of avail. The conjunctival sac should be carefully disinfected, the lips of the wound gently parted after removal of the slough and irrigated with a bichlorid solution, and the whole line of incision freely

cauterized with the actual cautery. In other words, the treatment is practically that which has been advised for a sloughing ulcer. At each subsequent dressing the lips of the wound should be parted with a probe and the anterior chamber drained. Internally quinin, iron, and milk-punch may be administered, and opium at night. Subconjunctival injections of bichlorid of mercury or cyanuret of mercury have been recommended under these circumstances, and recently the introduction of iodoform into the anterior chamber has been suggested, as in sloughing ulcers.

If the infection manifests itself in the form of a *ring abscess*, treatment is usually unavailing and the eye passes into a state of panophthalmitis and requires the treatment for that condition which has already been detailed. Suppuration, instead of beginning in the cornea, may sometimes commence in the iris and even in the vitreous, and the process go on to a destructive panophthalmitis.

*Iritis and Iridocyclitis*.—It is not uncommon for attachments to form between the capsule of the lens and the margin of the pupil or of the coloboma. These may be regarded as non-inflammatory synechiæ and are not of serious consequence. Iritis itself, with the usual symptoms of this condition, generally sets in about the fifth day, but may be delayed to the tenth day. It may be caused by an imperfect toilet of the wound, with the retention of pieces of cortex, and sometimes by too early exposure of the eye, but usually should be regarded as a manifestation of infection. If the ciliary body becomes involved and an *iridocyclitis* is set up, the gravity of the situation increases and the process may terminate in distortion and closure of the pupil, with exuded lymph. These cases of iridocyclitis may extend over weeks, sometimes better and sometimes worse, but finally the iris becomes dull and discolored and there is grave danger of sympathetic trouble in the opposite eye. Indeed, sympathetic ophthalmitis under these circumstances has been reported a number of times. *Late cyclitis*—that is, an inflammation occurring after the first week, is sometimes seen in the form of some deep-seated circumcorneal injection, thickening and opacity of the capsule,

and posterior synechiæ. Under treatment the symptoms may subside, or they may give rise to secondary glaucoma.

The *treatment* of these conditions in general terms should include bleeding from the temple by means of leeches, the free use of atropin, hot fomentations, the internal administration of full doses of salicylate of sodium, and under some circumstances mercury and iodid of potassium. If the process closes the pupil, when the eye becomes quiet iridectomy, iridotomy, or iridocystectomy may be required.

A remarkable condition to which Knapp has called special attention is the formation of a *spongy* or *gelatinous exudate* into the anterior chamber, associated at first with considerable pain, congestion of the conjunctiva, and edema of the margins of the lid. The manifestations are those of spongy iritis without an inflammation of the iris. The author has seen this twice. On both occasions the exudate disappeared and the result was good, although at first the appearances were most alarming.

*Bulging or Cystoid Cicatrix.*—Instead of perfectly smooth healing, the cicatrix at the end of a week or two may begin to bulge, sometimes at one or other extremity of the wound, and sometimes through its entire length. The bulging consists in a vesicle-like, semitransparent elevation, and is generally associated with an entanglement of the iris in its margins, together with distortion of the coloboma. Eyes in which such entanglement of the iris has taken place are likely to develop iridokeratitis, and therefore it has been recommended, especially by Berry, that the cystoid cicatrix should be removed and the opening closed by the application of the electro- or thermocautery.

*Glaucoma after Extraction.*—This complication occurs after a severe iritis, with numerous posterior synechiæ, which has led to the formation of a membrane. It may occur after the iritis, which is characterized by a deep anterior chamber and dotted opacities on the cornea, or also when the iritis is only slight in character, but when there has been an adherence of the pillars of the coloboma to the cicatrix and also to the lens-capsule. This tends to obliterate the canal of Schlemm.

Glaucoma also occurs after the operation of laceration of the capsule—*i. e.*, after discission. If uncontrolled by myotics, an iridectomy or sclerotomy should be performed.

*Opacities of the Cornea and Keratitis.*—Opacity in the cornea almost invariably is due to the injection of antiseptic fluid, especially strong solutions of bichlorid of mercury, into the anterior chamber. It has a peculiar, milky-white appearance, and is located chiefly at the posterior surface of the cornea, although the epithelium may also be rough. It does not disappear, and if sufficiently thick, entirely vitiates the effect of the operation.

This opacity must not be confounded with a very common type of keratitis occurring after cataract extractions, which has received the name *striated keratitis*, consisting of fine stripes of opacity radiating in several directions across the cornea. This entirely disappears in a few days, and need not give rise to apprehension. Occasionally at the end of a week or more *herpes of the cornea*, heralded by sharp pain and lacrimation, may develop, and from the herpetic spots small filaments may arise—*filamentous keratitis*. The lesions will subside under the influence of light bandages and antiseptic lotions.

*Prolapse of the Iris.*—This complication is the chief objection to the operation of simple extraction, and varies in frequency from 3 to 10 per cent., according to different statistics. The prolapse is usually heralded by a sudden sharp pain, which gradually passes away. It generally results from trauma—for example, striking the hand against the eye—or is due to a fit of coughing, violent exertion, straining effort, or similar cause. If the prolapse is discovered soon after its occurrence,—that is, at the first dressing,—it should be cut off and the edges of the iris reduced, exactly as after the operation of iridectomy. If the prolapse is not noted until the third or fourth day, it may be allowed to remain. The eye should be firmly but gently bandaged and atropin may be instilled, although some surgeons prefer eserin. Small prolapses may disappear, others produce no irritation, while still others become larger, constricted at their bases, or cystoid. Knapp

allows these to remain until the irritation has disappeared, and then amputates them in the same manner as a small staphylococcus is abscised, and usually has found smooth and permanent recovery. Occasionally iridocyclitis occurs, and sympathetic ophthalmitis has been reported.

Prolapse of the iris after combined extraction—*i. e.*, entanglement of the edge of the cut iris in the angle of the wound—is not uncommon.

*Slow Closure of the Wound.*—Often the wound after cataract extraction is closed at the end of twenty-four hours, usually not later than the third day. Occasionally, however, there is tardy closure, which in most instances is caused by some foreign substance—for example, a particle of capsule or conjunctiva between the lips of the wound. In other instances the failure to unite appears to be due to excessive secretion of aqueous humor or to lack of reparative power, depending upon some anomaly in the condition of the patient. A conservative treatment is generally indicated, and it is usually recommended that bandaging and rest in bed shall be continued until the wound closes, but the author agrees with Berry that if any dressing be applied at all when the wound does not close readily, it should be of the lightest character and should exert no pressure on the lids. If a piece of capsule or other foreign substance can be detected, it should, of course, be removed. In a few instances cauterization of the wound has been followed by good results. Associated with tardy or imperfect wound closure there may be a glossy edema of the conjunctiva in its lower part, which Knapp calls *filtration chemosis*. It will subside when the union of the incision is firm.

*Post-operative Insanity.*—Delirium after operation has been referred to. Sometimes marked dementia or insanity follows cataract extraction. It has been ascribed to the use of the bandage, to the effect of atropin, to the exaggeration of an imperfect mental balance existing prior to the operation, and to auto-infection. If possible, the bandage should be removed, and the patient given various calamatives, *e. g.*, the bromids, according to the indications.

**Choice of an Operation.**—Obviously, the advantages of simple extraction are the absence of mutilation of the iris, and consequently the formation of a round pupil which reacts freely to the changes of light and shade and prevents the dazzling so often caused by the presence of a coloboma. Its disadvantages are the difficulty of expelling the lens, the increased difficulty of performing perfect toilet of the wound, and the danger of prolapse of the iris. In the hands of operators of great experience the first two objections have little weight, and the tendency is to return to this mode of operating, Dr. Knapp stating that he does not think he shall ever cease to practise this simple extraction. In the judgment of the author certain cases require iridectomy—namely, those in which the ball is hard, the lens is large, the anterior chamber is shallow, the iris is not readily dilatable, or there is ciliary irritation. The combined method is also preferred when the cataract is not ripe or when the patient's mental or physical condition tends to create restlessness. Under other circumstances simple extraction is performed.

**Preliminary Iridectomy.**—Some operators, almost as a rule, perform a preliminary iridectomy and extract several weeks later, believing that this lessens the dangers of extraction. It is to be recommended in any case where serious complications are apprehended, or where for any reason an extraction in one eye has terminated unfavorably.

**Operations for After-cataract.**—After-cataract—or, as it is usually called, *secondary cataract*—has been described.



FIG. 260.—Knapp's knife-needle.

If it is a delicate, web-like membrane which stretches across the pupil, and which is best seen by artificial illumination,—*i. e.*, by condensing with a large magnifying-glass a beam of light into the pupillary space,—the treatment may consist in the introduction of a cataract needle in the manner described under *Discission*, and making a laceration in the membrane.

The author is accustomed to operate with Knapp's knife-needle (see Fig. 260) in the manner advised by this surgeon—namely:

The pupil being dilated *ad maximum*, thorough antisepsis having been secured, and the area of operation being perfectly illuminated, the knife enters the anterior chamber at a point on the horizontal meridian midway between the center and periphery of the cornea in an oblique direction, and the capsule is punctured at a point close to the opposite margin of the iris. An endeavor is made to form a crucial incision by first cutting horizontally through the capsule and then vertically. It is essential to cut the membrane, and not tear it and not drag upon the ciliary body. Therefore the instrument should avoid thickened portions of the capsule.

When the membrane is a thick one and there has been much proliferation of the epithelium, discission with a knife-needle, owing to the dense and resisting character of the tissues and the danger of dragging upon the ciliary body and iris, may not be sufficient, and, indeed, may be a dangerous operation. Under these circumstances iridotomy or iridocystectomy may be employed (page 689). Another plan is to introduce two needles at the opposite sides of the cornea, one serving to fix the membrane, while laceration is effected with the other. The needles may have a shoulder, and are known as stop needles, and the method as *Bowman's operation*. The method of the introduction of the needles and the manner of approximating their handles so as to cause a rent in the tissue are evident by an examination of Fig. 245.

Other plans are to divide the capsule with delicate cannula scissors, or to perforate the cornea and fix the membrane with a broad needle, and then, with a sharp hook introduced through a corneal opening at the opposite margin, to tear and roll up the membrane, which, if not too closely attached, may be drawn out with the instrument and cut away. The latter is the method of the late Dr. C. R. Agnew.

Discission is an operation invested with many dangers. Under no circumstances should there be rough handling; the discission instruments must be very sharp, and the operator must avoid dragging upon resisting bands. Preceding the operation and following it there should be the free use of

atropin. If signs of reaction occur, leeches and the treatment of iritis are indicated.

*Glaucoma after discission* is an occasional complication, and is characterized by pain, steamy cornea, impaired vision, and increased tension. It should be treated by eserine locally, morphin and chloral internally, and, if these measures fail, by iridectomy.

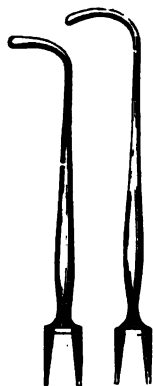
In cases of occlusion of the pupil by a drawing up of the iris, or where there are bands of strong inflammatory lymph, to which also the name secondary cataract is sometimes applied, discission is not advisable. In most instances iridotomy or iridocystectomy is the best operation.

#### OPERATIONS UPON THE EYE-MUSCLES.

These consist of *complete* and *partial tenotomy* and *advancement* or *readjustment*. For the operation of tenotomy the following instruments are required: A stop speculum or lid-elevator, two strabismus hooks (Figs. 261, 262), fixation forceps, and a pair of probe-pointed scissors, the form devised by Dr. Jackson being particularly suitable. In young children general anesthesia may be necessary; but, if possible, cocaine should be used. Usually the internal rectus is divided; quite frequently the external rectus; less commonly the other straight muscles.

**Complete Tenotomy.**—In a tenotomy on the internal rectus, for example, the operator proceeds as follows:

The eyelids being separated with a stop speculum, the surgeon catches with a fine-toothed forceps a fold of conjunctiva and subjacent fascia on a level with the lower border of the tendon, and with the probe-pointed scissors makes an opening just large enough to admit the strabismus hook. He may with one clip divide conjunctiva, subjacent fascia, and the capsule of Tenon; otherwise, after the division of the conjunctiva and subconjunctival tissue, Tenon's capsule must be picked up and incised in a length equal to the cut made in the overlying structures. The scissors are now laid down, and with his right hand the operator takes the strabismus hook and



FIGS. 261, 262.—Strabismus hooks.



insinuates it behind the tendon, the wound at the same time being held open with the forceps. After insertion the hook is pressed firmly against the sclerotic, and pushed between this and the tendon as far as the elbow of the instrument will permit. The point is then turned upward, and made to appear at the upper border of the tendon beneath the conjunctiva. It is now drawn forward and outward toward the cornea, and will be stopped by the insertion of the tendon. The operator now dispenses with the forceps, takes the hook in his left hand, renders the tendon tense, introduces the scissors, with their blades slightly parted, into the wound between the hook and the eye, and divides the tendon close to its sclerotic attachment by a number of slight cuts. After the section has been performed the hook should be swept through the opening in order to catch any strands which may have escaped the scissors. These should then be divided. This is the *subconjunctival operation*, and was introduced by Critchett.

Instead, the subconjunctival method, especially in cases where there is a considerable squint, the open operation, or, as it is known, the Graefe method, may be performed as follows:

The stop speculum having been introduced, the operator seizes with fixation forceps a fold of conjunctiva and subconjunctival tissue parallel with the corneal margin over the insertion of the tendon—that is, about 5 mm. from the margin of the cornea—and divides the tissue raised by the forceps horizontally down to the sclera. Next the point of a strabismus hook is pressed firmly against the sclera below and behind the insertion of the tendon, under which it is passed until it reaches its upper margin. With the hook in position the exposed tendon is put slightly upon the stretch and separated from its attachment by means of blunt-pointed scissors. The hook is next passed with its point turned above and below and any tendinous fibers which may have escaped are divided. The hook should now pass readily to the corneal margin. The surgeon can increase the effect of the operation by incising more or less freely the subconjunctival fascia, and also by dividing the fascia above and below the tendon, cutting upward and downward after the tendon itself has been separated from the sclerotic. But as has been pointed out (page 605), this practice is not to be commended. On the other hand, he may diminish the effect of the operation, if it is necessary, by inserting horizontally one or more conjunctival stitches. Sutures used for closing the wound should be inserted vertically.

After tenotomy the conjunctival sac should be thoroughly irrigated with boric acid solution or bichlorid of mercury (1 : 10,000), and both eyes bandaged for a day or two. The conjunctival suture may then be removed and the patient wear his correcting glasses. If the patient is in suitable surroundings, a bandage may be dispensed

with and the spectacles which correct the refractive error may be worn immediately after the operation. The latter procedure is followed by the best results. It is a mistake to bandage one eye.

Instead of using a hook to isolate the insertion of the tendon, this structure, after the conjunctival opening is made, may be seized and raised with forceps and divided in the usual manner, according to the method of Von Arlt.

Snellen's method of operating is satisfactory, and one which the author often employs. A small opening, about 4 mm. in width, is made through the conjunctiva over the insertion of the tendon, the center of which is then incised vertically. Through this opening the point of a strabismus hook is inserted and the upper and lower half of the tendon divided. A suture closes the conjunctival wound. Stevens's method, described on page 727, is a modification of this operation and may be used for complete as well as for partial tenotomies.

Panas recommends that the tendon shall be stretched before its division, gradual traction being made with the hook after it is inserted beneath the tendon until the internal border of the cornea reaches without resistance the external commissure of the lids. Both interni are divided, one immediately after the other. Edward Jackson suggests that after the division of the internus, a partial tenotomy of the superior or inferior rectus may be performed,—*i. e.*, a division of the inner third of the tendon,—in order to eliminate the accessory adducting power which these muscles exert in cases of convergent squint.

Tenotomy of the other straight muscles may be performed according to the methods already described, the operator remembering the distance of the insertion of each tendon from the corneal margin (page 562).

**Complications.**—1. The operator may fail to have divided the capsule of Tenon. Under these circumstances he will also fail to introduce the hook beneath the tendon, and by such failure will recognize that he has not sufficiently incised the tissues.

2. *Hemorrhage.*—Occasionally severe hemorrhage follows a

tenotomy, the blood rapidly pouring out beneath the capsule of Tenon and causing alarming proptosis. The pressure of the escaped blood may produce atrophy of the optic nerve. This accident is attributed to rupture of one of the ciliary arteries, and is less liable to occur in the Graefe method than in the sub-conjunctival operation. A firm pressure bandage should be applied, and gradually the proptosis will subside and the blood be absorbed.

3. *Orbital Cellulitis and Tenonitis*.—Cellulitis occurs from infection of the wound, the inflammation traveling back and causing an inflammation of the tissues of the orbit. Such an accident may be the result of an uncleanly operation. The treatment of orbital cellulitis, described in another section, is applicable. Tenonitis, or inflammation of the orbito-ocular fascia, has followed squint operations.

4. *Perforation of the Sclera*.—Although this is a rare accident, it has happened to operators of considerable experience. It is difficult to understand why it should occur unless sharp-pointed scissors were used, and for this reason the probe-pointed instrument is always to be preferred.

5. *Retraction of the caruncle*, so that it sinks away from its normal position and gives a most disagreeable and peculiar stare to the eye, is a very unfortunate occurrence after a squint operation. A very slight degree of this is liable to occur even after the most careful tenotomy. According to Schweigger, the best means to obviate its occurrence is to divide the fibers passing from the internus to the caruncle. When it exists in great degree, it is due in part to excessive dissection of the tissues, and in part to retraction of the muscle. There are several methods of overcoming this defect, the essential character of which is the loosening up of the contracted tissues and stitching the caruncle into place.

**Partial or Graduated Tenotomy**.—Graduated tenotomies are performed for the purpose of correcting those conditions which are described under heterophoria, when it is not deemed wise to perform a complete section of the tendon. The operation has been especially elaborated by Dr. Stevens, of New York, and is done as follows:

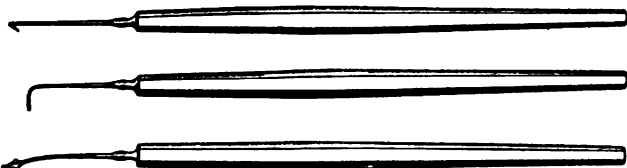
With a pair of small, narrow-bladed scissors a transverse incision is made through the conjunctiva exactly corresponding to the line of insertion of the tendon. This is seized behind, but near its insertion, and a small opening is made dividing the center of the tendinous expansion exactly on the sclera. This opening is then enlarged by careful cuts with the scissors toward each edge, keeping carefully on the sclera as the border of the tendon is approached; the amount to be cut depends upon the judgment of the operator



FIGS. 263, 264.



FIG. 265.



FIGS. 263-268.—Stevens's instruments for tenotomy.

and the need of the case, and is further regulated by placing the patient before a lighted candle and testing the sufficiency of the muscle upon which the operation is made, in the manner already described in connection with the investigation of heterophoria. In extreme cases, like strabismus, the surgeon may determine to continue his section through the border, leaving uninjured, as far as possible, both the anterior and posterior lamellæ of the capsule, as well as the expansion at each border, to hold the muscle in relation to the eye. Turning the scissors then in the direction of the other border, this portion is dissected with equal care.

The accompanying cuts illustrate the delicate instruments which are used in this operation. They may with equal pro-

priety be employed in ordinary tenotomies, and are satisfactory for this purpose, inasmuch as the laceration of the tissues is less marked, while the effect is equally great if the incisions are carried sufficiently far according to the directions already given.

**Advancement or readjustment** is an operation in which the tendon of a rectus muscle is brought forward to a new attachment. The operation is applicable to cases in which the tendon has become weakened—as, for instance, in myopia, together with the production of divergent squint; to those cases of convergent strabismus in which it is desirable to combine advancement of the external rectus with tenotomy of the internus; and to cases in which an injudicious division of the internal rectus, for instance, has converted a convergent into a divergent squint. For other indications see pages 604 and 606. General anesthesia may be necessary in young subjects and nervous patients.

The same instruments which are used in tenotomy are required, in addition to which suitable curved needles, a needle-holder, silk thread, fine catgut, and advancement forceps should be provided. Numerous methods of advancement have been designed: two will be described:

An opening is then made in the conjunctiva immediately over the insertion of the tendon which is to be advanced, twice the breadth of the tendon. A band of conjunctiva between the opening and the cornea is next separated with the scissors from the sclerotic. A strabismus hook is now passed under the tendon, which is freely separated from the sclera, and brought well up to its insertion, care being taken that the whole width of the tendon is held on the hook. A curved needle carrying a strong silk suture is introduced from its upper margin between the tendon and sclerotic, and passed through the tendon at its middle line. In the same way another suture is passed behind the tendon from its lower margin, and through it close to the first suture. Each of these sutures is knotted firmly on the tendon, a long end being left to each. In place of silk, catgut may be employed. For the strabismus hook is now substituted Prince's advancement forceps, which firmly grasps the tendon, which is next separated with scissors from the sclerotic close to its insertion, or the tendon may be held by means of the attached sutures. The needle on the end of each suture is now passed through the episcleral tissue and beneath the conjunctival flap to the margin of the cornea, and while an assistant rotates

the eyeball toward the muscle which is to be advanced, each suture is tied with its own end. If there is redundant tissue, it is trimmed away and the conjunctiva sewed with three interrupted sutures over

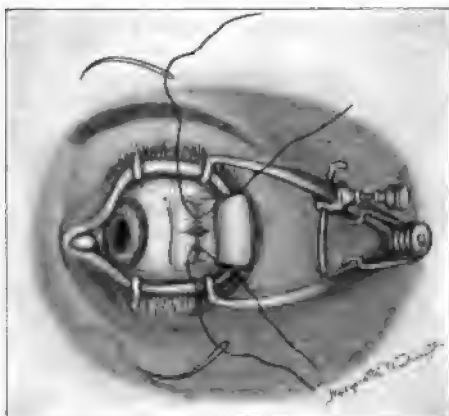


FIG. 269.—Advancement of the external rectus. The tendon has been exposed and the sutures tied upon it.

the advanced tendon. Naturally, a greater or less effect is produced according as the sutures are placed farther from or nearer to the insertion of the tendon, and according to the extent to which the

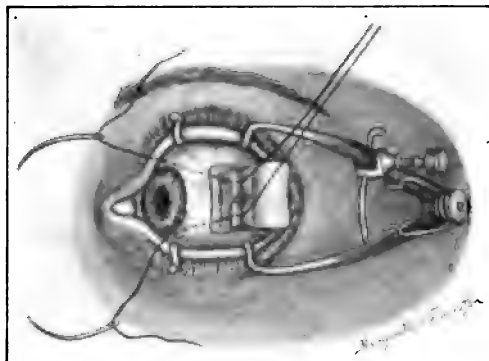


FIG. 270.—Advancement of the external rectus. The tendon has been separated from its scleral attachment, and the sutures will be passed through the episcleral tissue beneath the conjunctiva in the direction of the broken line.

loosened tendon is drawn toward the corneal margin. Both eyes are bandaged and should remain covered for at least four days, when the superficial sutures are removed. The deep sutures are allowed

to remain, if they produce no irritation, from eight to ten days. If black silk is used, they can readily be seen through the conjunctival covering and removed through a very small opening in its surface.

*Landolt's Method of Advancement.*—"The speculum having been adjusted, a conjunctival flap the summit of which reaches the edge of the cornea is cut and folded back so as to expose the insertion of the muscle which is to be advanced. Next a flattened hook is passed beneath the tendon and a second one in the opposite direction. The first hook is then withdrawn and the second intrusted to an assistant. Two sutures are now introduced from without inward, about one-third of the width of the muscle from either edge. These sutures also include the surrounding tissues. In *simple advancement* the sutures are introduced immediately behind the hook, and the insertion of the

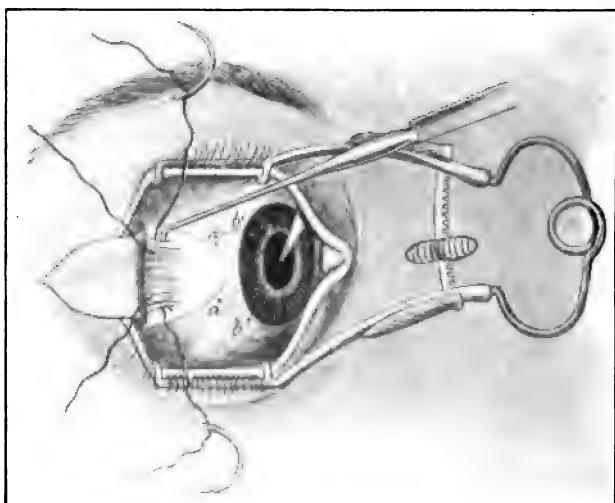


FIG. 271.—Landolt's method of advancement.

muscle is detached from the ocular globe. In a *resection* the sutures are introduced further back and the muscle divided between them and the hook. In order to accomplish this the muscle is gently raised,—at one part by means of the four ends of the stitches, which the surgeon holds in his left hand, and at the other by the hook which the assistant holds,—and the tendinous end separated from the eyeball. One of the needles is next passed above, and the other below, the meridian, into the *episcleral tissue* close to the corneal margin (*a-b*, Fig. 271), to the extent of several millimeters. If the needle does not penetrate sufficiently deep, it should be guided farther underneath the conjunctiva, and if it is feared that it has not a thorough grasp, it may be passed once more through the conjunctiva. The assistant now seizes the ocular globe with a fixation forceps at the

## Operation for Shortening the Tendon 731

level of the antagonistic muscle, and rotates it toward the muscle which is to be advanced, while the surgeon ties the sutures, one of which is composed of white silk and the other of black silk. Both eyes are bandaged for five days in divergent and a week in convergent strabismus. The sutures are usually removed on the sixth day."

In A. E. Prince's method of advancement an unyielding fixation point is obtained by utilizing the dense episcleral tissue, severing the muscle, and regulating the effect by a "pulley-suture." In Schweigger's method a free exposure of the muscle is made, and after the tendon is divided, a portion of the end is resected; catgut sutures are employed to advance the muscle.

Of the methods of advancement which have been recorded, the author is in the habit of employing the one which is described first, and with it has had most gratifying results.

Commonly the advancement has been associated with a tenotomy of the antagonist, although recently the advice of Landolt to perform advancement alone has been adopted in a number of cases.

*Advancement of the capsule of Tenon*, the tendon being folded on itself, has been practised by several surgeons (Wecker, Knapp).

**Operation for Shortening the Tendon.**—G. C. Savage and Francis Valk secure the advantages of advancement by an operation in which the tendon is shortened. The last-named surgeon operates as follows:

"The conjunctiva is raised with forceps over the lower or upper point of the insertion, of the tendon, and a vertical incision followed by a horizontal one forming an L, is made. This is dissected loose from the underlying tissue, and then an opening is made in Tenon's capsule and a small hook is passed beneath the tendon. As the point of the hook comes out, another hook is inserted in an opposite direction, and the two hooks forcibly drawn apart, thus exposing the tendon and part of the muscle. Next a small instrument called a twin strabismus hook is passed beneath the muscle, and the hooks are allowed to separate by the action of a small spring in the joint and the two hooks are then removed. The muscle and the tendon are now fully exposed and ready for the suture. A needle threaded with catgut is passed first through the lower part of the tendon, then through the muscle as far backward as it is desired to make the 'tuck,' passing from within outward. It then goes across the belly of the muscle and is passed through, from without inward and back



to the tendon, where it passes from within outward, at a point corresponding to its first insertion. As the ends are tied over the tendon at this point it is easy to see the 'tuck' formed as the muscle-belly is drawn forward and its long axis shortened."

#### OPERATIONS UPON THE LACRIMAL APPARATUS.

**Slitting the Canaliculus.**—This is performed as follows:

The lid being drawn down and out with the thumb, and the canaliculus knife held vertically, the probe point is introduced into

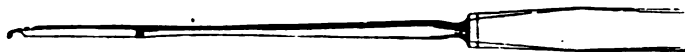


FIG. 272.—Weber's canaliculus knife.

the punctum. The handle is now depressed into the horizontal position, and the instrument pushed along the canal until the probe point touches the inner wall of the lacrimal sac. It is then raised to the vertical line with the cutting blade turned slightly inward, and the roof of the canaliculus divided. Either the upper or the lower canaliculus may be slit.

**Introduction of the Lacrimal Probe.**—The probe (Bowman's or Williams's probes are commonly employed, though



FIG. 273.—Introduction of a lacrimal probe (Meyer).

useful modifications have been devised by Theobald and Tansley) is introduced by passing it horizontally along the canalic-

ulus until its point touches the lacrimal bone. It is raised to the vertical position and pushed into the duct, remembering that the direction should be downward, slightly backward, and outward (Fig. 273).

**Incision of a Stricture.**—If the stricture resists, it may be divided with a knife, either the one which has been employed in slitting the canaliculus, or, still better, with the instrument of Stilling. The knife is introduced in the same way

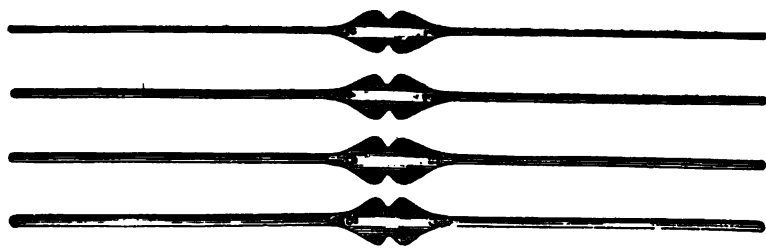


FIG. 274.—Lacrimal probes.

as the probe, pushed down into the duct, and the stricture incised. The knife is then partially withdrawn, turned slightly, and the manœuvre repeated. Dr. Charles Hermon Thomas, of Philadelphia, has devised a special knife, or *stricturotome*, which may be utilized for this purpose.

**Introduction of the Lacrimal Syringe.**—The nozzle of an Anel syringe can be introduced along the canaliculus without slitting it. The lid is drawn down and outward in the same manner as if the operation of slitting the canaliculus



FIG. 275.—Thomas's stricturotome.

were to be performed, and the point of the syringe introduced. Sometimes the punctum is swollen shut and the nozzle cannot be inserted. Under these circumstances the punctum may be dilated with a silver pin. Ordinarily a lacrimal syringe is furnished with a cannula probe. This is introduced into the duct in precisely the same manner as the solid probe; the syringe is filled with an antiseptic fluid, inserted into the mouth of the cannula, and the liquid injected into the duct.

**Excision of the Lacrimal Sac.**—In order to meet the indications described on page 631, excision of the lacrimal sac may be performed as follows:

After thorough cleansing of the sac through the canaliculus with a 1:10,000 bichlorid of mercury solution, general anesthesia is induced. With the skin drawn toward the bridge of the nose, the surgeon makes a slightly curved incision down to the periosteum, which extends from 4 mm. above the internal palpebral ligament to 5 mm. below it, its length being  $2\frac{1}{4}$  cm. The canthal ligament may be divided with scissors, and while the lips of the wound are separated, the temporal lip being especially drawn outward, the fibrous expansion from the tendo oculi is divided through its whole length, exposing the sac, which usually can be recognized by its bluish color. The sac is next gradually separated from the periosteum, being dissected out very much in the manner of removing a cyst, care being

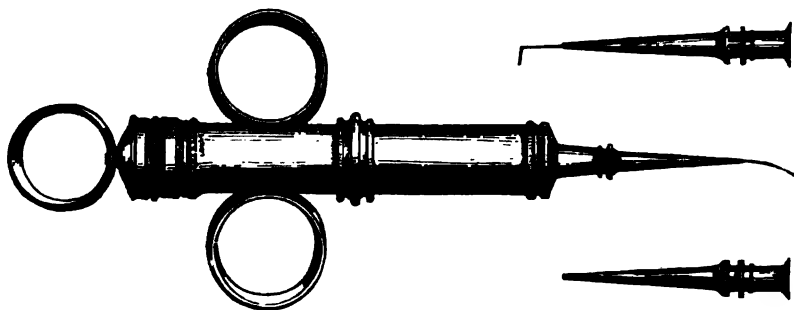


FIG. 276.—Anel syringe.

taken not to rupture its walls. The internal surface, the upper end and the posterior surface of the sac having been freed, is cut through at the commencement of the nasal duct. Sometimes the field of observation is obscured by a smart hemorrhage, which usually can be controlled by pressure or by specially devised specula. Should the operator experience any difficulty in outlining the sac, its position may be localized by inserting a probe.

C. R. Holmes does not believe it necessary to divide the tendo oculi in order to expose the sac, but dissects out the sac from underneath the tendon. If the tendo oculi has been severed, it may be replaced or repaired by a strong suture. Great care must be taken that every portion of the sac is removed, and the operation may be terminated by thoroughly curetting the region and the ductus ad nasum, removing all traces of mucous membrane. Two sutures close the wound, which usually heals promptly. Holmes advises that the canaliculi should also be destroyed. Otherwise a blind pocket forms at the inner canthus. In order to accomplish this he splits the canaliculi through their entire length and destroys their lining

membrane with the actual cautery. The dressing should consist of a pressure bandage placed over a light compress.

**Extirpation of the Lacrimal Gland.**—Following the direction of C. R. Holmes, this may be performed as follows :

An incision beginning near the center of the upper orbital arch and following the bony margin is carried to a point 3 mm. below the outer canthus. Next the fascia or septum orbitale is cut through along its attachment to the orbital margin. Should fatty tissue present in the wound, it must be held to one side with retractors and all bleeding from the edge of the wound must be controlled before the gland is separated from its surroundings, inasmuch as it is sometimes very difficult to distinguish the gland from the surrounding fatty tissue. By means of blunt-pointed scissors, fixation forceps, a small knife, and tenotomy hooks, the dissection of the gland can be accomplished and it may be removed without leaving any portion of it behind. Before the wound is closed all bleeding must be stopped. The lips of the wound are united with interrupted silk sutures, and the usual antiseptic dressing applied. As complications, hemorrhage into the orbit and atrophy of the optic nerve have been reported, and on a number of occasions a persisting conjunctivitis, and also, as, for example, in Veasey's case, a form of keratitis.

**Extirpation of the Palpebral Portion of the Lacrimal Gland.**—Instead of the removal of the orbital lacrimal gland, extirpation of the palpebral gland is often practised. It is a much simpler operation and may be performed as follows :

Thorough local anesthesia having been secured, the upper lid is everted and drawn upward from the eyeball while the patient looks strongly downward. This exposes the palpebral gland, which may be seized with toothed forceps and drawn outward. Its conjunctival covering is next incised, and the gland dissected from its surroundings. Hemorrhage having been controlled, the wound may be closed with one or two interrupted silk or catgut sutures, the upper lid replaced, and a light pressure bandage applied. The stitches are removed on the third day.

## APPENDIX.

**The Use of the Ophthalmometer.**—Ophthalmometry, or, more properly, keratometry, has been briefly referred to on page 131. A number of new models are now obtainable, with variations in the disc, form of arm, and method of illu-

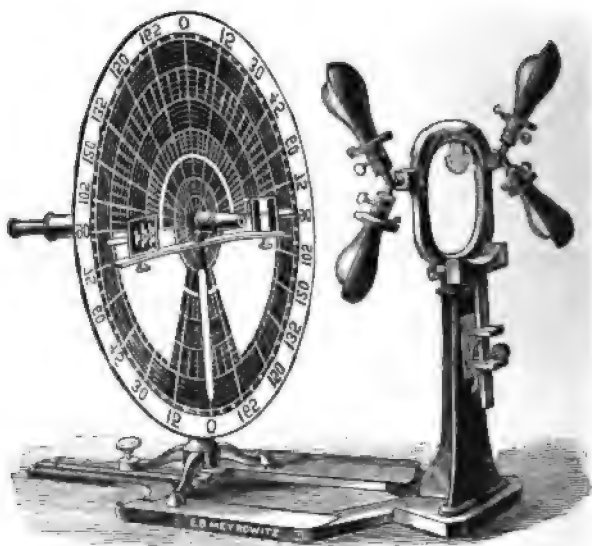


FIG. 277.—Javal-Schiötz ophthalmometer.

mination, but they do not introduce radical changes, and the following rules, prepared by Dr. E. W. Stevens, formerly associated with the author in the Philadelphia Polyclinic, will enable the student to understand the proper method of using this instrument :

The first requisite is a good light, and on a clear day that from a window with a northern exposure is sufficient ; but bright sunlight must not be utilized, as the reflection from the disc may cause reflex closure of the patient's lids. When available, artificial illumination

by electric light is equally satisfactory. The light must always be behind the patient, so that the disc and the mires (Fig. 278) of the instrument are fully illuminated; and, as the object is to study the reflection from the transparent cornea, there should be no source of light in front of the patient.

The examiner should first carefully adjust the telescope by looking through it and turning the eye-piece either to the right or the left until the cross-hairs are brought clearly into view. The telescope is then turned so that the long pointer is below and at zero. The stationary mire on the parallelogram (Fig. 278, *A*) should be examined to see that it is in proper position, which is at  $20^{\circ}$  on the graduated arc.

The patient is now seated before the instrument in an easy position, with his chin resting on the chin-rest and his forehead pressed against the forehead-rest. His eyes should be widely opened and exactly horizontal—points to be determined by sighting through

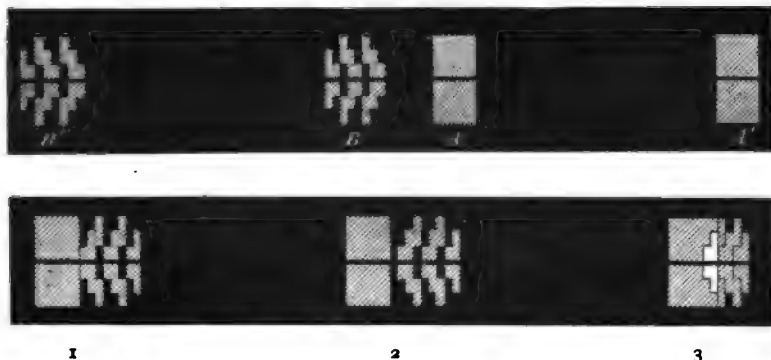


FIG. 278.—The mires.

the transverse slit above the telescope. One eye is now covered with a small shade, and the observer sights along the telescope, through the notch above it, at the patient's eyebrow; then sighting through the tube, he moves the instrument forward or backward and raises or lowers it by the thumb-screw until the eye is brought into the field of the telescope, and a distinct image of the disc and mires is seen on the cornea.

The images of the disc are doubled, and, overlapping each other, form an oval space in which are seen the two mires or targets, to which the beginner should confine his attention. The observer now slides the mire at his right along the arc until its reflection touches the reflection of the stationary mire, and notes whether the two lines bisecting the two mires are continuous. If these two lines are not continuous, the telescope is turned so that the long pointer will move from  $0^{\circ}$  toward  $135^{\circ}$ . If the transverse lines do not become continuous when  $135^{\circ}$  is reached, the rotation proceeds no farther

in this direction, but the long pointer is turned back to  $0^\circ$  and then toward  $45^\circ$ , but never beyond  $45^\circ$ . With regular astigmatism the lines always become continuous within  $45^\circ$  of  $0^\circ$ . When the lines are continuous the mires must be brought into perfect approximation (Fig. 278, 1). This is the *primary position*, which should be carefully recorded according to the position of the long pointer.

The telescope is now turned so that the long pointer moves  $90^\circ$  to the left of the primary position—*i. e.*, to a point which is known as the *second position*.

If the mires overlap (Fig. 278, 3),—for example, two steps in the second position with the long pointer at  $90^\circ$ ,—there is astigmatism of 2.00 D with the rule, because each step is equivalent to 1 diopter of corneal refraction, and this is recorded + 2.00 D cyl., axis  $90^\circ$ , or - 2.00 D cyl., axis  $180^\circ$ .

If, on the other hand, the mires separate (Fig. 278, 2) in the second position, there is astigmatism against the rule. For example, if the primary position is found at  $0.30^\circ$ , and when the tube is turned to the left until the long pointer reaches  $120^\circ$  a separation of one step has occurred, there is astigmatism of 1 diopter against the rule, which is recorded + 1.00 D cyl., axis  $30^\circ$ , or - 1.00 D cyl., axis  $120^\circ$ .

In order to ascertain the exact number of steps to which the separation of the mires in the second position is equivalent, they are approximated by moving the sliding mire until the reflections touch, and the telescope is then rotated back to the primary position. The mires will now overlap, and the amount of astigmatism can be read off just as in astigmatism with the rule. The observer should remember, when finding the primary position, not to turn the long pointer farther than  $45^\circ$  on each side of  $0^\circ$  at the lower margin of the disc, lest he record astigmatism against the rule when it is with the rule, and vice versa.

The upper surface of the arc carrying the mires is graduated on its outer circle to show diopters of refraction. It does not give the hyperopia or myopia of the eye, but indicates the corneal curvature. On the clamp of each mire there is a mark which enables one to read at a glance from this graduated arc the total refraction of each meridian of the cornea. The total refraction of at least one corneal meridian should be recorded, and preferably the one of least refraction. For example, if the examiner finds in the right eye 1 diopter of astigmatism with the rule, the long pointer being at  $75^\circ$  in the second position, and the right-hand mire at  $23^\circ$  on the graduated arc, the refraction may be recorded O. D. 43.00 D = 1.00 D cyl., axis  $75^\circ$  with the rule.

If so desired, the astigmatism can be read from the graduated arc by measuring alternately the meridians of greatest and least refraction of the cornea.

On the right of the inner circle of the arc there is a scale graduated from 6 to 10, each space being divided into ten equal parts. These spaces record the radius of curvature of the cornea in mil-

limeters, and the amount is indicated by a mark on the clamp of the traveling mire.

In some eyes it is impossible to bring into a continuous line the two lines bisecting the mires of the ophthalmometer, owing to irregular astigmatism or conical cornea. In these cases, however, the instrument is perhaps superior to all other methods of corneal measurement, as the overlapping or separation of the mires gives a clue to the axes of the meridians of least and greatest corneal curvature, as well as the amount of astigmatism.

Not infrequently the instrument indicates that the principal meridians of the cornea are not at right angles to each other—for example, it may record + 3.00 D cyl., axis 80°, or — 3.00 cyl., axis 180°. In these cases, when there is hyperopia, the axis of the cylinder should be 80°, and when there is myopia, 180°.

In patients with heavy overhanging lids, deep-set eyes, or long lashes it is at times extremely difficult, or even impossible, to measure the vertical meridian of the cornea with the ophthalmometer.

Nothing is more common than to see the mires separate and overlap again, so that the apparent curvature of the cornea seems to change while under observation. This change is due to slight movements of the eye which bring different portions of the cornea into view. It is difficult for most patients to remain long in the required position before the instrument, and hence the readings should be rapid as well as accurate.

As to the correspondence between the amount of corneal astigmatism indicated by the ophthalmometer and the total astigmatism under a mydriatic, there is a difference of opinion among observers. Probably the rule formulated by Burnett is, in the main, correct: "For the total subjective astigmatism, subtract 0.50 D from the corneal astigmatism when it is according to the rule, and add 0.50 D if the corneal astigmatism is against the rule."

Some years ago the author compared the corneal astigmatism in 200 eyes, measured with the ophthalmometer of Javal, with the total subjective astigmatism after complete mydriasis.

In 171 eyes in which it was possible to institute a comparison in the axis of the cylindric glasses obtained by the two methods of measurement, there was exact correspondence in 152 eyes, or 88.9 per cent., and failure in correspondence in 11.1 per cent.

In 171 eyes in which a comparison was made between the amount of corneal astigmatism determined by the instrument and the total astigmatism under a mydriatic, there was an ex-



act correspondence in 44 eyes, or 25.7 per cent., and failure in correspondence in 127 eyes, or 74.3 per cent.

In 109 eyes with astigmatism according to the rule, in which the astigmatism with the instrument was greater than the amount with mydriasis, the average increase was a little less than 0.50 D.

In 12 eyes with astigmatism contrary to the rule, in which the astigmatism with the instrument was less than the amount with mydriasis, the average decrease was again a little less than 0.50 D.

A precisely similar comparison was instituted by Dr. E. W. Stevens in the author's service in the Jefferson Medical College Hospital, and 400 eyes were examined with closely analogous results.

In 30 eyes in which with the ophthalmometer Dr. Stevens recorded no astigmatism, refraction under atropin also failed to develop astigmatism either with or against the rule. This is uncommon. Usually when the instrument fails to record astigmatism the patient will accept a weak cylinder, 0.25 or 0.50 D with the axis contrary to the rule.

The ophthalmometer is exceedingly useful, and one of the most important of all the instruments of precision we possess for the diagnosis of astigmatism of the cornea; but it should never be used for the prescription of glasses to the exclusion of other methods—the trial-lenses after mydriasis, and retinoscopy.<sup>1</sup>

**The Use of the Tropometer.**—Dr. G. T. Stevens<sup>2</sup> attaches special importance to the determinations, absolute as well as comparative, of the rotations of the eyes, since he believes that excessive tensions upon the vertically acting muscles of the eyes often induce converging or diverging strabismus, independently of any anomalous tension of the laterally

<sup>1</sup> For a thorough exposition of the principles of keratometry the student should consult Carl Weiland, *Archives of Ophthalmology*, vol. xxii., pp. 37–64; *Optique Physiologique*, by Tscherning, pp. 46–68.

<sup>2</sup> International Ophthalmological Congress, Edinburgh, August, 1894; *Annales d'Oculistique*, April and June, 1895.

acting muscles, and that many conditions of heterophoria may be explained in a like manner.

The most favorable rotations, according to Dr. Stevens, are—upward,  $33^{\circ}$ ; downward,  $50^{\circ}$ ; inward,  $55^{\circ}$ ; outward,  $50^{\circ}$  (compare with page 569).

He has devised an instrument, called the tropometer (Fig. 279), for the determination of the various rotations, a description of which, kindly revised by Dr. Stevens, follows:

The instrument consists essentially of a telescope in which an inverted image of the eye is found at the eye-piece, where its move-

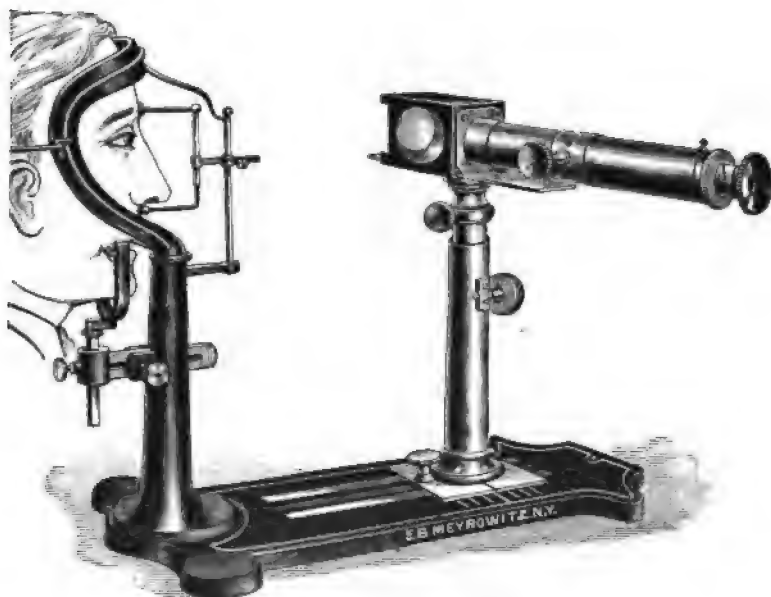


FIG. 279.—The tropometer.

ments can be observed upon a graduated scale, permitting rotations in any direction to be measured. A prism or a diagonal mirror at the objective end of the telescope permits the observer to sit at the side of the observed. By means of a head-rest and an adjustable stirrup with a wooden bar, which the observed holds closely between the teeth, the head may be held firmly in the primary position. This position is indicated by the two buttons at the extremities of the guiding rods.

*Explanation of Figure 280.*—The long line between and at right angles to the shorter lines divides two similarly graduated scales running in different directions.

The larger circle represents the outer border of the cornea, the edges of which are in contact with the two strong lines. The interval between each pair of short lines of the scale is ten degrees of an arc, commencing at the strong line in each case. If, now, the head of the person examined is held firmly in the primary position, and the eye caused to rotate strongly in a given direction, the arc through which the border of the cornea passes may be accurately read upon the scale. In the figure the curved dotted line represents a new position of the border of the cornea. Suppose that the person examined has been directed to look strongly upward. Then the cornea has moved *down* the scale, and reaches the point in this example of  $40^\circ$ , that being the measure of this rotation.

By means of the small lever the scale can be placed horizontally, vertically, or obliquely, and by means of the two graduations measurements in opposite directions can be made.

If it is desired to determine the upward rotation, the border of the cornea is made to coincide with the strong line which appears in the upper part of the scale

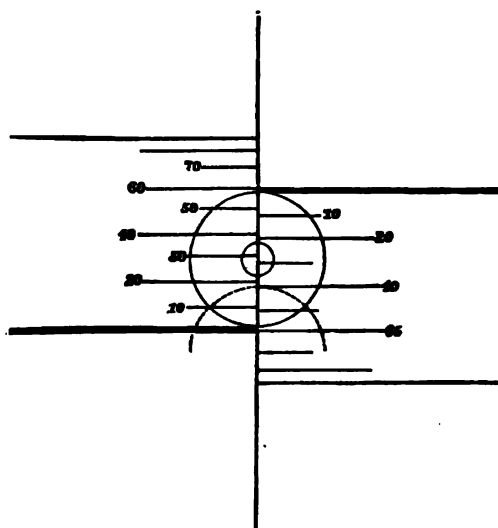


FIG. 280.

at the right hand. This adjustment is made by means of the milled head at the side of the standard. As the eye rotates up, the image moves apparently down. In determining the downward rotation the strong line at the lower left-hand side of the scale is taken as the point of departure. For lateral rotations the scale is turned to the horizontal position, and the corresponding strong lines used as before.

In order to adjust the upper border of the cornea to the line, it will generally be necessary for the examiner to place the left hand upon the forehead of the patient and make gentle traction of the upper eyelid by the thumb. An application of the hand to the head is advisable in all measurements, as by this means the examiner is

able to detect even a slight movement of the head, which would vitiate any measurement of the rotation.

In adjusting the head to the head-rest the teeth should be closed upon the wooden bar of the stirrup with force ; then, after adjusting the stirrup to the proper height, the two indicators should be adjusted, one touching the glabella or ridge just above the root of the nose, the other pressing the commissure of the upper lip close below the nose. By pushing the stirrup forward or backward the lower indicatory button should be at a distance from the bone equal to that of the upper indicator.

The hoop passing around the head is designed to indicate, when the knob presses against the occipital protuberance, that the head is in position for lateral measurements.

If the cornea is large, the telescope must be moved backward upon the base until the borders of the cornea just encroach upon the two strong lines of the scale. When the cornea is small the tube is moved forward.

The wooden bar of the stirrup may be thrown away after use and replaced by another.



# INDEX.

- ABDUCENS nerve**, 562  
     paralysis of, 619  
**Abduction**, 80, 562  
**Aberration**, 139  
**Ablatio retinae**, 490  
**Ablepharia**, 192  
**Abscess, lacrimal**, 624  
     of brain, 518  
     of cornea, 288  
     of eyelids, 194  
     of sclera, 332  
     prelacrimal sac, 624  
**Accommodation**, 41, 51, 75  
     amplitude of, 44, 75  
     and convergence, disturbance of, in  
         their relations, because of  
         squint, 595  
         relation between, 53  
     formula for obtaining the range of, 45  
     paralysis of, 438  
     paresis of, 543, 549  
     power of, 44  
     range of, 44, 46, 75  
     reflex of pupil, 64  
     relative, 53, 76  
         range of, 153  
     spasm of, 147, 152, 157  
     spastic, in iritis, 343  
**Achromatopsia**, 541, 546  
**Acoin**, 657  
**Acromegaly**, 519  
**Actinomyces** of lacrimal canal, 627  
**Actual cautery**, application of, 681  
     in corneal ulcers, 294  
     in infected scleral wounds, 339  
**Adams's operation** for ectropion, 670  
**Addison's disease**, 336  
**Adduction**, 80, 562  
     associated, 80  
**Adenoid vegetations**, 282  
**Adenoma of choroid**, 398  
     of eyelids, 205  
     of lacrimal glands, 622  
**Adrenalin**, 224, 250, 265  
     chlorid, 658  
**Advancement**, 728  
     in convergent concomitant strabismus,  
         604  
     in divergent strabismus, 606  
**Advancement in heterophoria**, 617  
     of capsule of Tenon, 731  
**After-cataract**, 443  
     operations for, 721  
**Agnew's operation** for after-cataract,  
     722  
**Albinism**, 378, 549, 618  
**Alcohol**, 587  
     amblyopia, 533, 545  
     -poisoning, 591  
**Allantiasis**, 587  
**Amauroses**, 539  
**Amaurosis**. See also *Amblyopia*.  
     from quinin, 545  
     partial fugacious, 551  
     uremic, 543  
**Amaurotic cat's eye**, 508  
     family idiocy, 509  
**Amblyopia**, 539  
     astigmatic, 540  
     central, 531. See also *Retrolubar*  
         *neuritis*.  
         with scotoma, 553  
     congenital, 439, 539  
         for colors, 540  
     exablepsia, 597  
     exanopsia, 540, 597  
     from alcohol, 533, 545  
     from arsenic, 534  
     from bisulphid of carbon, 534, 545  
     from blepharospasm, 540  
     from cannabis indica, 534, 545  
     from chloral, 534, 545  
     from chloroform, 534  
     from dental disease, 542  
     from diabetes, 534  
     from drugs, 545  
     from hemorrhage, 544  
     from iodoform, 534, 545  
     from lead, 534, 545  
     from male-fern, 545  
     from mercury, 545  
     from nitrate of silver, 545  
     from nitrobenzol, 534, 545  
     from opium, 534  
     from osmic acid, 545  
     from quinin, 545  
     from salicylic acid, 545  
     from stramonium, 534, 545

- Amblyopia from tobacco, 533, 545, 549  
   glycosuric, 543. See also *Amblyopia, diabetic*.  
   hysteric, 546  
   intoxication, 533, 534  
   malarial, 544  
   of squinting eyes, 596  
   of visual field, 551  
   pretended, 547  
     diplopia test for, 547  
     Harlan's test for, 547  
   reflex, 542  
   toxic, 533, 553, 554  
   traumatic, 542  
   uremic, 543  
 Amblyoscope, 603  
 Ametropia, 145  
   axial, 145  
   curvature, 145  
   retinal image in, 40  
 Amotio retinæ, 490  
 Amyotrophic lateral sclerosis, 528  
 Anemia, 66, 386, 456, 458, 464, 496, 513, 608  
 Anesthesia, general, 655  
   infiltration, 657  
   local, 655  
 Aneurysm, 67, 476, 587  
   of retinal vessels, 498  
 Angioid streaks in retina, 498  
 Angioma, cavernous, of choroid, 398  
   of conjunctiva, 270  
   of eyelids, 204  
   of conjunctiva, 270  
   of eyelids, 204  
   of orbit, 640  
 Angiosarcoma of conjunctiva, 273  
 Angiosclerosis, 437  
 Angle alpha, 47, 48  
   gamma, 47, 48, 157, 598  
   in hyperopia, 154  
   in myopia, 159  
   meter, 87. See *Meter angle*.  
   of convergence, 51  
   of deviation, 19  
   of incidence, 18  
   of refraction, 18  
   the visual, 39  
 Aniridia, 361  
 Anisocoria, 67  
 Anisometropia, 179  
 Ankyloblepharon, 214  
   congenital, 192  
 Anophoria, 77  
 Anophthalmos, 632  
 Anotropia, 77  
 Anterior chamber, angle of, in glaucoma, 417  
   anomalies of, 362  
 Anterior chamber, foreign bodies in, 362  
   irrigation of, after cataract extraction, 710  
   normal angle of, 417  
   parasites in, 362  
 Anthrax, 195  
 Antrum, disease of, 220  
   of Highmore, disease of, 520, 627, 649  
   empyema of, 649  
   fibroma of, 650  
   sarcoma of, 650  
 Aortic insufficiency, 66  
 Aphakia, 449  
   glasses in, 449  
 Aqua chlorini, 235, 236, 293  
 Aqueduct of Sylvius, 66  
 Aqueous humor, 144  
 Aquo-capsulitis, 355  
 Arcus senilis, 317, 319  
 Arecolin, 421  
 Argamblyopia, 540  
 Argentamin, 228, 235, 236, 237  
 Argyll-Robertson pupils, 67  
   reverse of, 67  
 Argyria conjunctivæ, 278  
 Argyrosis, 278  
 Aristol, 202, 260, 276, 296  
 Arlt's method of tenotomy, 725  
 Arsenic in tumors of orbit, 640  
 Arteriosclerosis, 269, 415, 456, 458, 496  
   general, ophthalmoscopic signs of, 497  
 Artificial eyes, insertion of, 693  
 Aspergillus fumigatus, 288  
 Asthenopia, 170  
   accommodative, 147, 613  
   muscular, 613  
   neurasthenic, 466  
   retinal, 547  
 Astigmatic chart, 174  
   eye, focusing of the vessels by the meridians of an, 126  
   form of the image of a point focused by an, 168  
 Astigmatism, 124, 131, 145, 155, 158, 166, 431, 512, 597, 619  
   according to the rule, 407  
   after cataract extraction, 449  
   compound, 126  
     hyperopic, 172, 175  
     myopic, 172, 176  
   contrary to rule, 168, 407, 449  
   correction of, 173  
   definition of, 167  
   designation of the meridians in, 178  
   irregular, 167, 178  
     skiascopy in, 139  
   mixed, 127, 172, 176

- Astigmatism, mixed, reading-glasses in, 183  
   myopic, 606  
     reading-glasses in, 183  
   oblique, 168  
   ordering of glasses for, 177  
   recognition of, 172  
   regular, 167, 171  
     principal meridians of cornea in, 168  
     skiascopy in, 137  
   seat of, 167  
   simple hyperopic, 126, 171, 175  
     myopic, 126, 171, 175  
   surgical treatment of, 179  
   symptoms of, 169  
   transient, in iritis, 342  
   with the rule, 168  
 Atheroma of carotid, 437  
 Atheromatous ulcers of cornea, 300  
 Atrabillin, 658  
 Atropin, 121, 141, 237, 240  
   in corneal ulcers, 292, 293  
   in iritis, 347, 348, 350  
 Atroscin, 143  
 Axes, secondary, 29  
 Axis, optic, 47  
   visual, 145  
  
 BACILLUS of influenza, 226  
   pyocyaneus, 288  
   pyogenes fetidus, 288  
 Bacterium coli, 230, 288  
 Bandages, 654  
 Bar-reading in strabismus, 603  
 Basedow's disease, 644  
 Beri-beri, 519  
 Bifocal lenses, 187, 188, 191  
 Binocular field of vision, 92  
   fixation, 76, 567  
   vision, method of testing, 607  
     single, 76, 567, 568  
 Bjerrum's method of ascertaining field of vision, 91  
 Blepharitis, 148, 198, 223, 265, 445, 622  
   acaria, 201  
   ciliaris, 199  
   etiology of, 200  
   hypertrophic, 200  
   pediculosa, 203  
   pustular form of, 200  
   simple, 199  
   squamous, 199  
   syphilitic, 203  
   treatment of, 201  
   trichophytica, 201  
   ulcerosa, 199, 200  
   vaccine, 196  
   vasomotor, 198  
   Blepharo-adenitis ciliaris, 199  
   Blepharochalasis, 213  
   Blepharophimosis, 215  
     congenital, 192  
   Blepharoplasty, 671  
   Blepharoptosis. See *Ptosis*.  
   Blepharospasm, 210, 216, 540, 547, 612  
   Blepharotomy, 664  
   Blind spot, Mariotte's, 96  
   Blindness, binocular, feigned, 548  
     feigned, 547, 548  
     hysteric monocular, 546  
   Blue-blindness, 541  
   Blue vision, 550  
   Boroglycerid, 250, 260  
   Botulismus, 587  
   Bowman's operation for after-cataract, 722  
   Brain, abscess of, 518  
     tumor of, 477, 518  
   Bright's disease. See *Nephritis*.  
   Bronchitis, 225, 304, 392, 415, 445  
   Bronchocele, 437  
   Brossage, 250  
   Bulbar paralysis, 528  
   Buller's shield, 238, 242, 247  
   Buphthalmos, 696. See *Hydrophthalmus*.  
   Burchardt's international tests, 69  
   Burns, cutaneous, retinal hemorrhage from, 496  
   Burrow's method of blepharoplasty, 672  
     operation for entropion, 668  
  
 CALCARINE fissure, 555  
 Campimeter, 89  
 Canal of Cloquet, 462  
 Canaliculi, acquired anomalies of, 622  
   congenital anomalies of, 622  
 Canaliculus, leptoithrix in, 623  
   polyp of, 623  
   slitting the, 732  
 Canthoplasty, 263, 664  
 Canthotomy, 240  
 Capsule of Tenon, advancement of, 731  
 Capsulopupillary membrane, 339  
 Carbolic acid in corneal ulcers, 294  
 Carbonic acid, 587  
 Carcinoma of brain, 518  
   of caruncle, 278  
   of choroid, 398  
   of ciliary body, 366  
   of conjunctiva, 273  
   of eyelids, 208  
   of lacrimal gland, 622  
   of orbit, 641  
 Caries of orbit, 634  
 Caruncle, abscess of, 277  
   affections of, 277



- Caruncle, carcinoma of, 278  
   cylindroma of, 278  
   dermoid of, 278  
   fibroma of, 278  
   lymphangioma of, 278  
   retraction of, after tenotomy, 726  
   sarcoma of, 278
- Cataract, 62, 156, **480**, 543  
   accidents during extraction of, 713  
   after-, 443. See also *Cataract, secondary*.  
   after-treatment of extraction of, 712  
   among glass-blowers, 437  
   anomalies in healing process after extraction of, 715  
   anterior capsular, 441  
     polar, 442  
       congenital, 441  
   artificial ripening of, 447  
   astigmatism after extraction of, 449  
   black, 439  
   capsular, 443  
   capsulolenticular, 444  
   catoptric test in, 432  
   causes of, 436  
   central, 441  
   cholesterin crystals in, 439  
   combined extraction of, 448, 703  
   complete, of young people, 439  
     treatment of, 448  
   complicated, 442  
   concussion, 438, 443  
   conditions determining operations on, 444  
   congenital, **480**, 540, 597  
     treatment of, 448  
   cortical, 430, 434  
   couching, 699  
   course of, 434  
   cystoid cicatrix after extraction of, 718  
   development of, 434  
   diabetic, 436, 437, 439  
   diagnosis of, 432  
   discission of, 448, 699  
   erythropsia after extraction of, 550  
   examination of light-field in, 444  
   extraction of, 365, 369, 448, 702  
     after sympathetic inflammation, 376  
     through corneal incisions, 704  
     without capsulotomy, 704  
   filtration chemosis after extraction of, 720  
   from diseases of eye, 438  
   from ergotism, 437  
   from lightning-stroke, 438  
   from naphthalin, 437  
   fusiform, 442  
   glasses after extraction of, 449  
   glaucoma after extraction of, 718
- Cataract, hard, 436, 439  
   hyaloid, 439  
   immature, 434, 438. See also *Cataract, incipient*.  
     treatment of, 446, **447**  
   incipient, 223, 444  
   infection after extraction of, 716  
   influence of heredity in formation of, 437  
   insanity after extraction of, 720  
   intra-ocular hemorrhage after extraction of, 715  
   iritis after discission of, 355  
     after extraction of, 355, 717  
   juvenile, 439  
   keratitis after extraction of, 719  
   lamellar. See *Cataract, zonular*.  
   linear extraction of, 448, 702  
   massage in treatment of, 446  
   mature, treatment of, 448  
   method of determining when ripe, 433  
   mixed, 435  
   monocular, treatment of, 448  
   Morgagnian, 436  
   needle operation for, 699  
   nephritic, 437  
   nuclear, 430, 435  
   operations for, 699  
   pathology of, 434  
   posterior polar, 381, 437, 442, 486  
     congenital, 441  
   preparation of patient for extraction of, 705  
   primary, 430  
   prognosis of, 444  
   prolapse of iris after extraction of, 719  
   punctate, 441  
   pyramidal, 232, 441  
   raphanic, 437  
   reclination of, 699  
   ripe, 433  
   secondary, 430, 442, 443. See also *Cataract, after-*.  
     operations for, 721  
   senile, 438  
   simple extraction of, 448, 703  
   slow closure of wound after extraction of, 720  
   soft, 436, 438  
   spongy exudate into anterior chamber after extraction of, 718  
   spontaneous disappearance of, 444  
   suction method of removing, 448, 701  
   suppuration of wound after extraction of, 716  
   symptoms of, 431  
   technic of extraction of, 707-712  
   traumatic, 323, 438, **442**

- Cataract, treatment of, 446  
 varieties of, 430  
 zonular, 440  
   treatment of, 448  
 Catoptric test, 432  
 Cautery. See *Actual cautery*.  
 Cavernous sinus, disease of, 587  
   thrombosis of, 519, 638  
 Cellulitis of orbit, 636  
   orbital, 269  
     after tenotomy, 726  
 Center of rotation, 47  
 Centrad, 20, 52  
   relation of, to meter angle, 52  
 Cephalocele, 641  
 Cerebellum, tumors of, 518, 618  
 Cerebritis, 519  
 Chalazion, 206  
   cause of, 206  
   pathology of, 206  
   removal of, 658  
   symptoms of, 206  
   treatment of, 207  
 Cherry-red spot in macula, 499  
 Chiasm. See *Optic chiasm*.  
 Chloracetic acid, 209  
 Chloral, 587  
 Chlorin-water, intra-ocular injections of,  
     454  
 Chloroform, 282  
 Chlorosis, 386, 467  
 Choked disc. See *Optic neuritis*.  
 Cholera, 464  
 Cholesteatoma of iris, 358  
 Chondroma of lacrimal gland, 622  
 Chorea, 613  
 Chorioretinitis, 552  
 Choroid, 120  
   adenoma of, 398  
   alveolar sarcoma of, 395  
   calcification of, 369  
   carcinoma of, 398  
   cavernous angioma of, 398  
   chronic tuberculosis of, 398  
   colloid changes in, 387, 388  
   coloboma of, 377  
   congenital anomalies of, 377  
   congestion of, 148, 378  
   detachment of, 397, 400  
   diseases of, 377  
   enchondroma of, 398  
   endothelioma of, 395  
   extrapapillary coloboma of, 371  
   foreign bodies in, 334, 399  
   gyrate atrophy of, 485  
   hemorrhage into, 400  
   hyperemia of, 378  
   injuries of, 399  
   macular coloboma of, 377  
   ossification of, 369, 401  
   perithelioma of, 395  
   ring, 113  
   rupture of, 399, 438  
   sarcoma of, 393, 427, 492, 508  
     diagnosis of, 396  
     prognosis of, 397  
     treatment of, 397  
   sclerosis of vessels of, 387  
   senile areolar atrophy of, 387  
   tubercle of, 398, 508  
   tumors of, 393  
   verruccosities of, 387  
   wounds of, 399  
   "Choroidal dust," 398  
     fissure, 340, 377  
 Choroiditis, 269, 879, 438, 444, 450,  
     456  
   acute, 382  
   ametropic, 388  
   anterior, 330  
   atrophic, 380  
   causes of, 385  
   central, 386  
   character of pigment in, 381  
   chronic, 382  
   course and complications of, 381  
   deep, 383  
   diagnosis of, 380  
   diffuse exudative, 888  
   disseminated, 310, 884, 385, 386,  
     442, 552  
   epithelial, 382  
   exudative, non-suppurative, 382  
   from injury, 386  
   guttate, 387  
   hemorrhagic, 389  
   hereditary, 386  
   intra-uterine, 325, 377  
   myopic, 389  
   pathology of, 381  
   plastic, 382  
   prognosis of, 381, 386  
   purulent, 382, 475. See *Choroiditis*,  
     *suppurative*.  
   recent, 380  
   serous, 382, 416  
   superficial, 382  
   suppurative, 382, 891  
     causes of, 392  
   symptoms of, 380  
   treatment of, 382, 386  
   unclassified forms of, 388  
 Choroidoretinitis, 381, 383, 385, 427  
   atrophic, 470  
   central, from ametropia, 540  
   sympathetic, 371  
   syphilitic, 473  
 Chromatometer, 75

- Chromidrosis, 219  
 Cilia. See *Eyelashes*.  
 Ciliary body, 416  
   carcinoma of, 366  
   foreign bodies in, 334  
   gumma of, 366  
   injuries of, 365  
   myoma of, 366  
   ossification of, 366  
   sarcoma of, 366, 397  
   tumors of, 366  
   wounds of, 369  
   congestion, 58, 341  
   muscle, 41  
   processes, 42  
   vessels, anterior, 58  
 Cilioretinal vessels, 117  
   in embolism of central artery, 500  
 Cilium forceps, 658  
 Cinnamate of sodium, 325  
 Cinnamic acid, 680  
 Cleft eyelid, 192  
 Climacteric, 308, 476  
 Cloquet, canal of, 462  
 Cobalt glass test, 83  
 Cocain, 121, 142, 248, 282, 305, 348, 655  
   in corneal ulceration, 292  
   solution, sterilization of, 655, 656  
 Coloboma, extrapapillary, 377  
   macular, 377  
   of choroid, 377  
   of iris, 339, 377, 540, 549  
   of lens, 430  
   of sheath of optic nerve, 510  
   palpebræ, 192  
 Color-blindness, 71, 540  
   Hölmgren's method of detecting, 71  
   lantern test for, 73  
   special tests for, 75  
   Thomson's method of detecting, 73  
 Color-field of vision, 93  
 Color-sense, 71  
 Colors, direct vision for, 75  
 Concave lens, virtual image of a, 31  
 Conical cornea, 155, 319, 362  
   operative treatment of, 39  
   optical treatment of, 319  
 Conium, 212, 213, 587  
 Conjugate deviation of head and eyes, 593  
   foci, 26  
   of concave lenses, 28  
   lateral paralysis, 593  
 Conjunctiva, abscess of, 269  
   acute blennorrhœa of, 229, 238  
   amyloid disease of, 267  
   angioma of, 270  
   angioneurotic edema of, 269  
   Conjunctiva, angiosarcoma of, 273  
   argyria of, 278  
   atrophy of, 266  
   blood-vessels of, 58  
   burns of, 277  
   carcinoma of, 273  
   cavernous angioma of, 270  
   chancre of, 270  
   chemosis of, 269, 633  
   congenital anomalies of, 223  
   cysticerci of, 272  
   cysts of, 270, 271  
   dermoid of, 270  
   diseases of, 223  
   ecchymosis of, 269  
   eczema of, 247  
   edema of, 269  
   emphysema of, 270  
   endothelioma of, 273  
   epithelioma of, 272  
   erythema of, 550  
   essential shrinking of, 267, 276  
   fibroma of, 271  
   folliculosis of, 250  
   foreign bodies in, 277  
   hemorrhage beneath, 269  
   hyperemia of, 223  
   symptoms of, 224  
   treatment of, 224  
   injuries of, 277  
   lepra of, 273  
   lime-burns of, 277  
   lipoma of, 271  
   lithiasis of, 265  
   lupus of, 273  
   lymphangiectasis of, 270  
   lymphangioma of, 270  
   lymphatic follicles of, 253  
   lymphoma of, 264  
   naevus pigmentosus of, 271  
   operations on, 675  
   osteoma of, 271  
   papilloma of, 271  
   pigment spots of, 270  
   sarcoma of, 271, 273  
   siderosis of, 278  
   streptococcus diphtheria of, 245  
   syphilis of, 270  
   tuberculosis of, 273  
   tumors of, 270  
   ulcer of, 269  
   wounds of, 277  
   xerosis of, 266, 302  
 Conjunctival sac, temperature of, 59  
   vessels, anterior, 59  
   posterior, 58  
 Conjunctivitis, 148, 224, 269  
   acute contagious, 226  
   diagnosis and prognosis of, 227

- Conjunctivitis, acute contagious, etiology  
     of, 226  
     symptoms of, 227  
     treatment of, 229  
     mucopurulent, 226  
 angular, 263  
 associated, 225  
 atropin, 266  
 calomel, 248  
 catarrhal, 225  
 caterpillar hair, 266  
 chronic, 242, 264, 445  
 croupous, 243  
     causes of, 243  
     diagnosis of, 244  
     symptoms of, 244  
     treatment of, 244  
 diphtheritic, 214, 238, 245, 267  
     causes of, 245  
     symptoms of, 245  
     treatment of, 246  
 diplobacillus, 263  
 Egyptian, 252, 265  
 exanthematous, 225  
 follicular, 250  
     causes of, 250  
     symptoms of, 251  
     treatment of, 251  
 from anilin dyes, 266  
 from chrysophanic acid, 266  
 from exposure to electric light, 550  
     to the X-rays, 550  
 gonorrheal, 238  
     diagnosis of, 239  
     metastatic, 243  
     prognosis of, 239  
     prophylaxis of, 242  
     symptoms of, 239  
     treatment of, 239  
 granular, 252, 267, 275, 276, 445, 622  
     causes of, 252  
     diagnosis of, 258  
     excision of retrotarsal fold in, 261  
     expression operation for, 678  
     follicular, 254  
     general medication in, 263  
     grattage in, 679  
     mixed, 255  
     nature of granulations of, 253  
     non-inflammatory follicular, 255  
     operation of expression for, 261  
     operations for, 678  
     operative procedures in, 261  
     papillary, 254  
     prognosis of, 259  
     sclerosing, 255  
     sequels of, 258  
     symptoms of, 255  
     treatment of, 259
- Conjunctivitis, granular, varieties of, 254  
 hemorrhagic catarrhal, 227  
 Koch-Weeks' bacillus, 226  
 lacrimal, 265, 623  
 mechanical, 225  
 membranous, 243  
 military, 252, 265  
 neonatorum, 229, 291, 442  
     diagnosis of, 234  
     prognosis of, 234  
     prophylaxis of, 234  
     symptoms of, 230  
     treatment of, 235  
 Parinaud's, 264  
 petrificans, 268  
 phlyctenular, 247, 344  
     causes of, 247  
     symptoms of, 247  
     treatment of, 248  
 plastic, 243  
 pneumococcus, 227  
 prognosis and duration of simple, 226  
 pseudomembranous, 243  
 purulent, 229, 238, 454  
 recurring form of, 244  
 simple, 225, 344  
 spring, 249  
     causes of, 249  
     symptoms of, 249  
     treatment of, 250  
 subacute, 263  
 symptomatic, 225  
 symptoms of simple, 225  
 syphilitic, 270  
 tea-leaf, 229  
 toxic, 266  
 treatment of simple, 228  
 vernal, 249  
 xerosis of, 258
- Connective-tissue ring, 113  
 Constipation, 456  
 Conus, 116, 158, 390, 511  
     underlying, 116  
 Convergence, 50  
     amplitude of, 53, 87  
     and accommodation, relation between, 53  
     angle of, 51  
     far point of, 53  
     insufficiency of, 571, 609  
     caused by convex glasses, 610  
     near point of, 53, 80, 87  
     paralysis, 609  
     power of, 87  
     reflex of pupil, 64  
     spasm of, 589  
 Convergence-excess in esophoria, 609  
 Convex lens, virtual image of a, 30  
 Copper in eye, 334

- Corectopia, 338  
 Corelysis, 358  
 Cornea, 144  
   abscess of, 288  
   absorption ulcer of, 285  
   acute serpiginous ulcer of, 286  
   annular ulcer of, 290  
   atheromatous ulcers of, 300  
   atrophy of, 291  
     margin of, 319  
   blood-staining of, 319, 362  
   burns and scalds of, 324  
   causes of infective ulcers of, 287  
   changes in, in exophthalmic goiter, 645  
   chronic serpiginous ulcer of, 290  
   circular ulcer of, 290  
   congenital anomalies of, 325  
     melanosis of, 326  
     opacities of, 325  
     staphyloma of, 326  
   conical, 155, 319  
   creeping ulcer of, 286  
   cyst of, 324  
   dendriform ulcer of, 290  
   dermoid of, 324  
   diameter of, in glaucoma, 415  
   diseases of, 279  
   eczema of, 279  
   edema of, 403  
   epithelioma of, 324  
   erosions of, 322  
   examination of, by transmitted light, III  
   excavated ulcer of, 285  
   exhaustion ulcer of, 291  
   fibroma of, 324  
   fistula of, 301  
   foreign bodies in, 321  
   fungus-infection of, 288  
   herpes of, 304  
     after cataract extraction, 719  
   indolent ulcer of, 285  
   infantile ulceration of, with xerosis of conjunctiva, 302  
   infecting ulcer of, 286  
   injuries of, 321  
   inspection of, 59  
   lepra of, 273  
   leukoma of, 298  
   macula of, 298  
   marginal ring ulcer of, 290  
   massage of, 301  
   nebula of, 298  
   normal diameter of, 415  
   papilloma of, 324  
   paracentesis of, 241, 293, 295, 680  
   phlyctenular ulcer of, 280  
   powder grains in, 321  
   Cornea, primary opacity of, 318  
     principal meridians of, 168  
     prognosis of ulcers of, 291  
     purulent ulcer of, 285  
     relapsing herpes of, 315  
       erosion of, 306  
     reparative ulcer of, 286  
     results of ulceration of, 298  
     rupture of, 333  
     sarcoma of, 324  
     sclerosis of margin of, 319  
     sensitivity of, 60  
     simple ulcer of, 285  
     sloughing ulcer of, 286  
     small central ulcer of, 285  
     staphyloma of, 284, 299, 300  
     tattooing of, 302, 683  
     transverse calcareous film of, 318  
     treatment of results of ulceration of, 31  
       of ulcers of, 291  
   tuberculosis of, 289  
   tumors of, 324  
   ulcers of, 232, 240, 243, 277, 288, 369, 392, 438, 442, 444, 636, 657  
   vertical meridian of, 564  
   width of, 60  
   wounds of, 323  
 Corneal loupe, 61  
 Corneitis. See *Keratitis*.  
 Corpora geniculata, 555  
   quadrigenina, 66, 555  
   tumor of, 518  
 Corresponding points of retina, 568  
 Couching cataract, 699  
 Counterfield, 467  
 Credé's method, 234  
 Creolin, 229  
 Crescents, semiatrophic, 390  
 Critchett's method of tenotomy, 723  
   operation, 376  
 Croton-chloral, 198  
 Cryptophthalmos, 192  
 Crystalline lens. See *Lens, crystalline*.  
 Cuneus, 555  
 Cyclitis, 59, 62, 310, 362, 868, 443, 456, 492. See also *Iridocyclitis*.  
   after cataract extraction, 717  
   causes of, 365  
   pathology of, 36  
   plastic, 363, 366  
   prognosis of, 365  
   purulent, 364  
   serous, 355, 356, 364, 367  
   symptoms of, 363  
   traumatic, 365  
   treatment of, 365

- Cyclitis, varieties of, 363  
 Cyclophoria, 78, 83, 608, 614  
 Cyclopia, 632  
 Cycloplegia, 593  
     unilateral, 593  
 Cylindric lenses, 34  
 Cyllindroma of caruncle, 278  
     of lacrimal gland, 622  
 Cyst, congenital, of iris, 340  
     dermoid, of eyelid, 220  
     of cornea, 324  
     of eyebrow, 220  
     of iris, 358  
     of orbit, 641  
     sebaceous, of eyelid, 220  
 Cysticerci in vitreous, 461  
     of conjunctiva, 272  
 Cysticercus in anterior chamber, 362  
     intra-ocular, 369  
     of retina, 492, 509  
 Cystoid cicatrix, 424, 453  
     after cataract extraction, 718  
 Cysts of conjunctiva, 270, 271
- DACRYOADENITIS, 620  
     acute, 620  
     suppurative, 620  
 Dacryocystitis, 293, 628  
     acute, 624  
     blepharorrheic, 624  
     catarrhal, 624  
     of infants, 626  
     phlegmonous, 624  
 Dacryolith, 622  
 Dacryops, 622  
 Dalrymple's sign in goiter, 645  
 "Danger zone," 365, 369  
 Day-blindness, 549  
 Dementia, 445  
 Demodex folliculorum, 201  
 Dendriform ulcer of cornea, 290  
 Dennett's method of numbering prisms, 20  
 Dermatol, 296  
 Dermoid cyst of eyelid, 220  
     of orbit, 641  
     of caruncle, 278  
     of conjunctiva, 270  
     of cornea, 324  
 Descemetitis, 314, 355  
 Descending neuritis, 516  
 De Wecker's campimeter, 89  
     operation for staphyloma, 682  
 Diabetes, 156, 352, 436, 458, 494, 496, 528, 532, 543, 587, 591  
 Diachylon ointment, 202  
 Dieffenbach's method of blepharoplasty, 672  
 Dilator pupillæ, 65
- Dionin, 297, 421, 657  
 Diopter, the, 32  
 Dioptric apparatus, 144  
 Diphtheria, 519, 587, 594, 638  
 Diplobacillus, 288  
     conjunctivitis, 263  
     of Morax and Axenfeld, 263  
 Diplococcus intracellularis meningitidis, 454  
 Diplopia, 98, 179, 565, 571, 574, 575, 598  
     binocular, 599  
     crossed. See *Diplopia, heteronymous*.  
     heteronymous, 573, 576  
     homonymous, 571, 576  
     horizontal, 576  
     in concomitant strabismus, 599  
     monocular, 547, 619  
     in cataract, 432  
     paradoxical, 599  
     simple. See *Diplopia, homonymous*.  
     table of, in ocular muscle paralysis, 585  
     test for pretended amblyopia, 547  
     varieties of, 575  
     vertical, 576  
 Direct method of ophthalmoscopy, 103, 109  
     formation of image in, 105  
     size of image in, 106  
 Discission, 369  
     glaucoma after, 723  
     of after-cataract, 721  
     of cataract, 699  
 Disseminated sclerosis, 67, 519, 528, 532, 587, 592, 618  
 Distichiasis, 215, 258  
     congenital, 193  
 Divergence-excess, 609  
 Divergence-insufficiency, 609  
 Divergence-paralysis, 589  
 Dressings, 653  
 Drusen in papilla, 537  
 Duboisin, 141, 266  
 Ductus ad nasum. See *Nasal duct*.  
 Dyschromatopsia, 541, 542, 546  
 Dysentery, 392  
 Dyspepsia, 319, 613
- EAR, disease of, 587  
 Ecchymosis of conjunctiva, 269  
     of eyelids, 221  
 Ectasia scleræ, 329  
 Ectopia lentis, 450  
 Ectropion, 216, 622  
     acute, 216  
     chronic, 216  
     congenital, 193

- Ectropion, congenital, of uvea, 340  
 operations for, 670
- Eczema, 225, 244, 280  
 of conjunctiva, 247  
 of cornea, 279  
 of eyelid borders, 199  
 of eyelids, 196  
 seborrhoicum, 201
- Edema, angioneurotic, of conjunctiva, 269  
 of eyelids, 220  
 essential, of eyelids, 221  
 of conjunctiva, 269  
 of eyelids, 220
- Electric light, effect of, on retina, 505
- Ophthalmia, 550
- Electricity in paralytic strabismus, 590
- Electrolysis, 206, 250  
 for trichiasis, 665  
 in angiomas, 204  
 in granular conjunctivitis, 262  
 in lacrimal diseases, 630
- Electromagnet, 335
- Elephantiasis Arabum of eyelids, 210
- telangiectodes of eyelids, 210
- Embolism of central artery of retina, 498, 552
- Emmetropia, 144  
 retinal image in, 40  
 skiascopy in, 137
- Emphysema of conjunctiva, 270  
 of eyelids, 221
- Empyema of antrum, 649  
 of frontal sinus, 646
- Encanthis, 277
- Encephalocele. See *Cephalocele*.
- Enchondroma of choroid, 398  
 of orbit, 640  
 of sclera, 332  
 of tarsus, 205
- Endocarditis, 392, 496
- Endocular cauterization, 336
- Endothelioma of choroid, 395  
 of conjunctiva, 273  
 of lacrimal gland, 622  
 of optic nerve, 536  
 of orbit, 641
- Enophthalmos, 98, 651
- Entropion, 258  
 congenital, 193  
 operations for, 667  
 spastic, operations for, 667
- Enucleation of eyeball, 302, 332, 374, 397, 690  
 during panophthalmitis, 392  
 implantation after, 696  
 preventive, 374
- Eosin, 60
- Ephedrin-homatropin, 143
- Ephidrosis, 219
- Epicanthus, 193
- Epilepsy, 437, 488, 613
- Epiphora, 622
- Episcleritis, 327  
 fugaceous periodic, 328  
 treatment of, 328
- Epistaxis, 544
- Epithelioma of conjunctiva, 272  
 of cornea, 324  
 of eyelids, 208  
 of lacrimal gland, 622  
 of orbit, 642
- Erysipelas, 194, 225, 464, 519, 637, 646
- Erythropsia, 549, 550
- Eserin, 152, 237, 240, 266  
 in conical cornea, 320  
 in corneal ulcers, 293  
 in glaucoma, 421, 422  
 in scleritis, 328, 331
- Esophoria, 77, 608, 609, 611  
 tests for, 78  
 with convergence-excess, 609  
 with divergence-insufficiency, 609
- Esotropia, 77. See *Strabismus, convergent*.
- Ethmoid, disease of, 220, 520, 532, 647  
 mucocele of, 647  
 osteoma of, 642  
 retention-cyst of, 647
- Ethmoiditis, 647
- Eucaïn, 656
- Euphthalmin, 121, 142
- Europhen, 296
- Everbusch's operation for ptosis, 663
- Evisceration, 375  
 during panophthalmitis, 392  
 of eyeball, 694  
 with insertion of artificial vitreous, 695
- Exenteration of orbit, 697
- Exophoria, 77, 153, 157, 179, 608, 609, 610, 611  
 tests for, 78  
 with convergence-insufficiency, 609  
 with divergence-excess, 609
- Exophthalmic goiter, 213, 644  
 nature of, 645
- Exophthalmos, 632, 634  
 pulsating, 643
- Exostosis of orbit, 642
- Exotropia, 77. See *Strabismus, divergent*.
- Expression operation for trachoma, 678
- External rectus, 562  
 paralysis of, 576, 588  
 tenotomy of, 725  
 in myopia, 163
- Extorsion, 562, 563

- Extraction of cataract, 702.** See also *Cataract, extraction of.*  
 accidents during, 713  
 after-treatment of, 712  
 anomalies in healing process after, 715  
 cystoid cicatrix after, 718  
 filtration chemosis after, 720  
 glaucoma after, 718  
 insanity after, 720  
 intra-ocular hemorrhage after, 115  
 iritis after, 717  
 keratitis after, 719  
 prolapse of iris after, 719  
 slow closure of wound after, 720  
 spongy exudate into anterior chamber after, 718  
 suppuration of wound after, 716  
 technic of, 707-712  
 with iridectomy, 703  
 without capsulotomy, 704  
 without iridectomy, 703
- Eye, aberration of, 139**  
 axis of, 166  
 circulation of fluids in, 416  
 direct inspection of, 56  
 emmetropic, 24  
 equator of, 167  
 hyperopic, 24  
 meridians of, 167  
 muscles, operations upon, 723  
 myopic, 24  
 poles of, 166  
 visual axis of, 145
- Eyeball, atrophy of, 233, 365, 401**  
 dislocation of, 650  
 enucleation of, 302, 374, 397, **690**  
 accidents during, 692  
 implantation after, 696  
 evisceration of, 694  
 with insertion of artificial vitreous, 695  
 foreign bodies in, 334, 369  
 massage of, in glaucoma, 422  
 penetrating wounds of, 332  
 prognosis of foreign bodies in, 335  
 retraction movement of, with congenital defects in ocular muscles, 588  
 siderosis of, 376  
 treatment of foreign bodies in, 335  
 wounds of, 332
- Eyeballs.** See also *Eyes.*  
 movements of, 562, 564
- Eyebrow, cysts of, 220**
- Eyelashes, epilation of, 658**  
 sudden turning gray of, 216
- Eyelid, malignant pustule of, 195**  
 method of evertng, 57
- Eyelid, abscess of, 194**  
 absence of, 192  
 adenoma of, 205  
 alopecia of, 216  
 angioma of, 204  
 angioneurotic edema of, 220  
 anthrax of, 195  
 burns of, 221  
 carcinoma of, 208  
 cavernous angioma of, 204  
 chancre of, 203  
 chromidrosis of, 219  
 cleft of, 192  
 congenital anomalies of, 192  
 cutaneous horns of, 205  
 cysts of, 204  
 dermoid cysts of, 220  
 diseases of, 192  
 ecchymosis of, 221  
 eczema of, 196  
 edema of, 220, 649  
 elephantiasis of, 210  
 emphysema of, 221  
 ephidrosis of, 219  
 epithelioma of, 208  
 erysipelas of, 194  
 erythema of, 194  
 essential edema of, 221  
 exanthematous eruptions of, 196  
 fat hernias of, 205  
 favus of, 201  
 fibroma of, 205  
 furuncle of, 195  
 glandular carcinoma of, 208  
 gumma of, 203  
 hyperemia of borders of, 198  
 hypertrophies of, 204  
 injuries of, 220  
 lepra of, 210  
 lipoma of, 205  
 lupus of, 207  
 vulgaris of, 210  
 malignant edema of, 195  
 marginal eczema of, 199  
 milium of, 218  
 molluscum contagiosum of, 219  
 fibrosum of, 205  
 neuroma of, 205  
 operations on, 658  
 papilloma of, 204  
 postvariolous ulcer of, 196  
 powder-burns of, 222  
 rodent ulcer of, 207, 208  
 sarcoma of, 207  
 sebaceous cysts of, 220  
 seborrhea of, 218  
 of border of, 199  
 spreading gangrene of, 195  
 syphilis of, 203



- Eyelid, tertiary ulcers of, 203  
   tumors of, 204  
   warts of, 204  
   wounds of, 220  
 Eye-muscles, balance of external, 76  
   latent deviation of, 76  
   manifest deviation of, 76  
 Eyes. See also *Eyeballs*.  
   artificial, insertion of, 693  
   associated movements of, 567  
     parallel, 80  
   mobility of, 76  
   position of the, 98  
     primary, 563  
     secondary, 564  
 Eye-strain, 147, 170, 378, 532  
  
 FACIAL nerve, paralysis of, 213, 217  
   paralysis, 622  
 Far point, 43, 45, 75  
 Favus of eyelids, 201  
 Fetal cleft. See *Choroidal fissure*.  
 Fibers of Gratiolet, 555  
   of Wernicke, 555  
 Fibroma of antrum, 650  
   of caruncle, 278  
   of conjunctiva, 271  
   of cornea, 324  
   of eyelids, 205  
   of lacrimal glands, 622  
   of optic nerve, 536  
   of orbit, 640  
   of sclera, 332  
 Field of fixation, 569  
   of vision, 87  
     abnormalities of, 96  
     amblyopia of, 551  
     binocular, 92  
     Bjerrum's method of ascertaining, 91  
     false projection of, in paralytic strabismus, 575  
     for colors, 93  
     in glaucoma, 407  
     in hysteria, 547  
     in optic-nerve atrophy, 525  
     in retinal anesthesia, 467  
     methods of ascertaining, 87-91  
     relative, 92  
 Filaria sanguinis hominis, 362  
   in vitreous, 461  
 Filtration scar, 426  
 Fistula, buccal, 625  
   capillary, of lacrimal sac, 625  
   of lacrimal sac, 625  
 Fixation, binocular, 76, 567  
   field of, 569  
   line of, 47  
 Flimmer-scotom, 551  
  
 Fluorescein, 60, 681  
   test in uveitic inflammations, 371  
 Foci, conjugate, 26  
 Focus of a concave lens, 27  
   conjugate, 28  
   principal, 27  
   of a convex lens, 25  
   conjugate, 26  
   principal, 25  
   virtual, 27  
 Folliculosis, 250  
 Foreign bodies in choroid, 399  
   in eyeball, 334  
   in iris, 360  
 Formaldehyd, 228, 236, 292, 293  
   in corneal ulcers, 294  
 Form-sense, 70  
 Förster's method of ripening cataract, 447  
 Fourth nerve. See *Trochlear*.  
 Fovea centralis, 47, 50, 118  
   vicarious, 599  
 Foveal reflex, 118  
 Fox's operation of implantation, 697  
 Fränkel-Weichselbaum capsulated diplococcus, 227  
 Fricke's method of blepharoplasty, 673  
 Friedreich's ataxia, 528, 618  
 Frontal sinus, disease of, 520, 646  
   empyema of, 646  
   mucocoele of, 646  
   osteoma of, 642, 646  
 Frost-Lang operation of implantation, 696  
 Frühjahr's catarrh, 249  
 Functional testing, 55  
 Fungus hematodes, 508  
 Furuncle of eyelid, 195  
 Fusion, 568  
   faculty, defective development of, because of squint, 598  
  
 GALVANISM, 316, 489  
   in corneal opacities, 301  
   in herpes zoster, 198  
   in heterophoria, 613  
   in optic-nerve atrophy, 531  
 Galvanocautery, 322. See also *Actual cautery*.  
   in corneal ulcers, 294  
 Gamo Pinto's operation, 296  
 Gangrene of eyelids, 195  
 Gasserian ganglion, disease of, 303  
 Gelsemium, 212, 213, 587  
 Gerontoxon, 319  
 Gifford-Galassi reflex, 68  
 Glaucoma, 58, 66, 160, 305, 314, 318, 362, 365, 383, 402, 438, 444, 459, 552, 657, 696

- Glaucoma, absolute, 413**  
   acute, 344, 411  
     period of incubation of, 411  
   after discission, 723  
   after extraction of cataract, 718  
   alteration of refraction in, 407  
   attack, 412  
   causes of, 415  
   chronic, 332. See *Glaucoma, simple chronic.*  
     congestive, 413  
       treatment of, 424  
   inflammatory. See *Glaucoma, chronic congestive.*  
   complicated, 428  
   congenital, 321, 429  
   congestive. See *Glaucoma, acute.*  
   diagnosis of, 419  
   edema of cornea in, 403  
   -excavation, 404, 406  
   field of vision in, 407  
   from injury, 415  
   from mydriatics, 416  
   fulminans, 413  
   halo, 404  
   hemorrhagic, 362, 428  
   inflammatory. See *Glaucoma, acute.*  
   iridescent vision in, 411  
   light-sense in, 420  
   malignant, 425  
   non-inflammatory. See *Glaucoma simple chronic.*  
   pathogenesis of, 416  
   posterior, 419  
   primary, 402  
   prognosis of, 420  
   pulsation of vessels in, 405  
   ring, 404  
   rise of tension in, 402  
   scleral puncture in, 423  
   scotomas in, 409  
   secondary, 163, 402, 427, 443  
   simple chronic, 414  
     treatment of, 424  
   subacute. See *Glaucoma, chronic congestive.*  
   symptoms of, 402  
   treatment of, 421  
     by excision of sympathetic ganglion, 426  
   varieties of, 402  
   visual acuity in, 407  
   with cataract, 428  
   with myopia, 428  
**Glaucomatous state, 412**  
**Glioma endophytum, 506**  
   exophytum, 506  
   of brain, 518  
   of optic nerve, 536  
**Glioma of retina, 396, 506**  
   tension in, 508  
**Goiter, exophthalmic, 644**  
**Gonococcus of Neisser, 230, 352**  
**Gonorrhea, 329, 351, 519**  
**Gould's prism exercises in heterophoria, 615**  
**Gout, 223, 318, 328, 329, 351, 365, 368, 415, 437, 456, 459, 496, 532, 587**  
**Graefe's dot and line test, 79**  
   method of tenotomy, 724  
   operation for ptosis, 660  
   sign in goiter, 644  
**Grandmont's operation for ptosis, 663**  
**Granular lids. See Conjunctivitis, granular.**  
**Grattage, 261, 679**  
**Graves's disease, 98, 644**  
**Green vision, 550**  
**Green-blindness, 72, 541**  
**Grut's theory of strabismus, 597**  
**Gumma of brain, 518**  
   of iris, 353  
   of lids, 203  
   of optic nerve, 536  
**Gunn's dots, 118**  
**Gymnastic exercises with prisms, 614**  
**HAAB's magnet, 335, 360, 452**  
   reflex, 67  
**Habit chorea, 212**  
**Hardy ophthalmometer, 131**  
**Harlan's operation for symblepharon, 677**  
   test for pretended amblyopia, 547  
**Hasner d'Artha's method of blepharoplasty, 673**  
**Hay-fever, 223**  
**Headache, 148, 158, 170, 466, 612, 633, 646**  
**Heart disease, 415, 476, 496**  
**Helmholtz's ophthalmoscope, 102**  
   theory of accommodation, 42  
   of color-blindness, 541  
**Hematoma of dura mater, 518**  
   of orbit, 641  
**Hemeralopia, 549**  
**Hemialepsia. See Hemianopsia.**  
**Hemiachromatopsia, 559**  
**Hemianopia, 464. See Hemianopsia.**  
**Hemianopsia, 551, 554**  
   absolute, 559  
   altitudinal, 556  
   binasal, 557  
   bitemporal, 557  
   homonymous, 557  
   double, 559  
   horizontal, 556

- Hemianopsia, peculiarities of the dividing-line in, 559  
 pupil in, 561  
 relative, 559  
 significance of, 559  
 varieties of, 556  
 vertical, 556
- Hemiopia. See *Hemianopsia*.
- Hemiopic pupillary inaction, 67, 561
- Hemophilia, 362, 496
- Hemoptysis, 544
- Hemostasis, local, 657
- Hering's theory of color-blindness, 541
- Herpes corneæ, 304  
 relapsing, 315  
 of cornea after cataract extraction, 719  
 zoster, 587  
   ophthalmicus, 197, 369  
   corneal lesions in, 197  
   treatment of, 198
- Herschel's prism, 81
- Heterophoria, 77, 328, 607  
 causes of, 608  
 cobalt glass test of, 83  
 comparative value of various tests for, 86  
 correction of refractive errors for relief of, 614  
 difference between it and heterotropia, 611  
 equilibrium test for, 79  
 method of examination, 613  
 operations for relief of, 617  
 orthoptic exercises in, 617  
 parallax test for, 78  
 prism test for, 78  
 prisms in, 615  
 relative frequency of, 610  
 rod test of, 84  
 screen test of, 78  
 symptoms of, 612  
 tests for, 78-87  
 treatment of, 613
- Heterophorias, classification of, 77
- Heterophthalmos, 338
- Heterotropia, 76, 77. See also *Strabismus*.
- Hetol, 325, 680
- Heurteloup, 348
- Hippus, 68
- Hirschberg's electromagnet, 335
- Holmgren's method of detecting color-blindness, 71
- Holocain, 305, 656  
 in corneal ulceration, 292
- Homatropin, 121, 141, 266
- Hordeolum, 195  
 treatment of, 196
- "Hot-eye," 329
- Hotz-Anagnostakis operation for entropion, 668
- Hotz's operation for trichiasis, 666
- Hunt's operation for ptosis, 662
- Hutchinson's teeth, 310
- Hyaline bodies in papilla, 537
- Hyalitis, 345, 458  
 asteroid, 457  
 punctata, 456  
 suppurative, 453
- Hyaloid artery, 462  
 persistent, 462  
 membrane, hemorrhage under, 494
- Hydrastin, 260
- Hydrocephalus, 519
- Hydrophthalmos, 821, 429, 439
- Hyoscin, 141  
 in iritis, 348
- Hyoscyamin, 141, 266  
 in iritis, 348
- Hyperesophoria, 77
- Hyperesotropia, 78
- Hyperidrosis, 219
- Hypermetropia. See *Hyperopia*.
- Hyperopia, 110, 124, 130, 145, 512, 597  
 absolute, 146  
 amount of shortening of eye caused by, 124  
 angle gamma in, 154  
 aphakial, 146  
 axial, 146  
 causes and varieties of, 146  
 correction of, 148  
   with skiascopy, 152  
   with test-types and trial-lenses, 150  
   with the ophthalmoscope, 152  
 curvature, 146  
 determination of, 148  
 facultative, 146  
 latent, 146  
 manifest, 146  
 ordering of glasses for, 152  
 passing to myopia, 383  
 skiascopy in, 136  
 symptoms of, 147  
 total, 146
- Hyperopic disc, 512
- Hyperphoria, 77, 179, 610, 611  
 accommodative, 608  
 central, 608  
 comitant, 610  
 concomitant, 608  
 non-comitant, 610  
 parietic, 608  
 spasmodic, 608  
 varieties of, 608
- Hypertropia, 78, 573, 594
- Hyphema, 362

- Hypopyon, 265, 277, 284, 286, **287**, 302, 362  
 Hypopyon-keratitis, 287  
 Hysteria, 467, 546, 552, 607, 619  
   visual signs of, 546, 547
- ICHTHARGAN, 260  
 Ichthyol ointment, 198, 202  
 Ichthyosis, 276  
 Identical points, 50  
 Idiocy, 488  
 Illumination, oblique, 60  
 Image, size of the, in direct method of using ophthalmoscope, 106  
   in indirect method of using ophthalmoscope, 108  
 Impetigo contagiosa, 225, 244  
 Implantation of artificial globe in Tenon's capsule after removal of eyeball, 696  
   into orbit after remote enucleation of eyeball, 697  
 Index of refraction, 18  
 Indirect method, estimation of refraction by, 130  
   of ophthalmoscopy, 106, 127  
   formation of image in, 108  
   size of image in, 108  
 Inferior oblique, 563  
   paralysis of, 579  
   rectus, 562  
   paralysis of, 580  
   tenotomy of, 725  
 Influenza, 226, 244, 415, 437, 519, 532, 587, 591, 620, 637, 646  
 Insanity, 67, 512  
   after cataract extraction, 720  
 Insomnia, 415, 613  
 Instruments, preparation of, 653  
 Insufficiency of ocular muscles. See *Heterophoria*.  
 Internal rectus, 562  
   paralysis of, 577  
   tenotomy of, 723  
 Intestinal hemorrhage, 544  
 Intorsion, 562, 563  
 Intra-ocular injections, 375, 454  
   in detachment of retina, 493  
 Iodid of silver, 260  
 Iodin, 305  
   in corneal ulcers, 294  
 Iodoform, 236, 241, 246, 260, 276  
   in corneal ulcers, 294, 296  
   in tubercular iritis, 359  
   use of, in anterior chamber in sloughing ulcers, 295  
 Iodol, 296  
 Iridectomy, 179, 308, 314, 332, 356, 369, 502, **688**  
 Iridectomy in detachment of retina, 493  
   in glaucoma, 422  
   in hemorrhagic glaucoma, 428  
   in hydrophthalmos, 321  
   in sympathetic inflammation, 375  
   intra-ocular hemorrhage after, 496  
   optical, 302  
   in cataract, 447  
   preliminary to cataract extraction, 721  
   preventive, 424  
   varieties of, 687  
 Irideremia, 340, 549  
 Iridochoroiditis, 345, **867**, 381, 403, 438  
   chronic serous, 367  
   plastic, 357  
   suppurative, 382, **891**  
   sympathetic serous, 371  
 Iridocyclitis, 265, 286, 305, 318, 345, **868**, 438, 456, 492, 657, 696  
   after cataract extraction, 717  
   anterior, 418  
   malignant, 371  
   serous, 356  
   sympathetic, 371  
   traumatic, 369  
 Iridocystectomy, 689, 722  
 Iridodesis, 369  
 Iridodialysis, 360  
   congenital, 338  
 Iridodonesis, 341  
 Iridoplegia, 66, 594  
   reflex, 67  
   unilateral reflex, 67  
 Iridotomy, 375, **687**, 722  
   V-shaped, 689  
 Iris, anteversion of, 361  
   bombe, 345  
   bridge coloboma of, 349  
   cholesteatoma of, 358  
   chromatic asymmetry of, 62  
   coloboma of, 339, 377, 540, 549  
   color of, 62  
   complete detachment of, 361  
   congenital atrophy of, 340  
   cyst of, 340  
   cysts of, 358  
   diseases of the, 338  
   displacement of, 361  
   foreign bodies in, 360  
   functional motor disorders of, 340  
   granuloma of, 359  
   gumma of, 353, 366  
   hyperemia of, 341  
   implantation cysts of, 358, 362  
   injuries of, 360  
   leprosy of, 360  
   lymphoma of, 360

- Iris, melanoma of, 359  
   mobility of, 63  
   nevus of, 340, 360  
   operations upon, 683  
   papilloma of, 340  
   pearl-cysts of, 358  
   pearl-tumor of, 358  
   prolapse of, 233, 241, 296, 323, 369  
     after cataract extraction, 719  
   pseudocoloboma of, 340  
   retention cysts of, 358  
   retroflexion of, 361  
   rupture of continuity of, 361  
     of sphincter of, 361  
   sarcoma of, 359  
   serous cysts of, 358  
   tubercle of, 358  
   tumors of, 358  
   wounds of, 360
- Iritis, 58, 62, 163, 243, 269, 286, 310, 318, 341, 403, 419, 438, 443  
   after cataract extraction, 717  
   catamenialis, 354  
   chronic, 356  
   course and complications of, 344  
   diabetic, 352  
   diagnosis of, 343  
   fibrinous, 347  
   from dental irritation, 354  
   from eserine, 355  
   from nasal suppuration, 354  
   gonorrheal, 351  
   gouty, 351  
   gummatous, 353  
   idiopathic, 354  
   infectious disease, 354  
   iridectomy in, 357  
     in chronic, 357  
     in recurrent, 357  
   operative treatment in, 357  
   papulosa, 352, 353  
   parenchymatous, 352  
   pathology of, 346  
   periodic, 354  
   plastic, 347  
     treatment of, 348  
   prognosis of, 344  
   purulent, 354  
   quiet, 350  
   recurrent, 350  
   rheumatic, 350  
   scrofulous, 354  
   secondary, 355  
   serous, 355, 362, 367  
   spongy, 347  
   sympathetic, 355  
     serous, 371  
   symptoms of, 341
- Iritis, syphilitic parenchymatous, 352  
   plastic, 347  
   traumatic, 323, 355  
   treatment of, 347  
   tubercular, 354
- Irotomy, 687
- JACKSON'S magnifying lens, 62  
 Jacob's ulcer, 208  
 Jaeger's type, 75  
 Jaesche-Arlt operation for trichiasis, 665  
 Javal-Schiotz ophthalmometer, 131, 736  
 Jequirity, 262
- KALT'S irrigations, 240  
 Kataphoria, 77  
 Katatropia, 77  
 Keratalgia, traumatic, 306  
 Keratitis, 279, 323  
   after cataract extraction, 719  
   annularis, 317  
     et disciformis, 317  
   bullosa, 305  
     relapsing traumatic, 306  
   circumscribed parenchymatous, 315  
   dendritica, 290  
   fascicular, 281  
   filamentous, 318  
     after cataract extraction, 719  
   from schizomycetol infection, 288  
   grill-like, 317  
   hypopyon, 287  
   interstitial, 59, 62, 305, 308  
     abscess forms of, 312  
     atypical forms of, 312  
     causes of, 308  
     central annular, 312  
     congenital form of, 309  
     diagnosis and prognosis of, 312  
     symptoms of, 309  
     treatment of, 313  
   leprous, 273  
   maculosa, 315  
   malarial, 291  
   marginal, 281  
     phlyctenular, 290  
     vascular, 312  
   marginalis, 316  
   neuromyolytic, 303  
   nodosa, 266  
   nummular, 316  
   oyster-shucker's, 322  
   parenchymatous, 197, 308  
   petrificans, 318  
   phlyctenular, 279  
     causes of, 279  
     diagnosis and prognosis of, 281  
     pathology of, 281  
     symptoms of, 280

- Keratitis**, phlyctenular, treatment of, 282  
 profunda, 315  
 punctata, 312, 814, 345, 355, 362, 367  
 riband-like, 318  
 scar, 300  
 sclerotizing, 317, 330  
 striated, 719  
 strumous, 308  
 syphilitic, 308  
 subepithelialis centralis, 315  
 superficialis punctata, 315  
 suppurative, 289  
 traumatic, 321  
 trophica, 318  
 vascular, 258, 807  
 vesiculosa, 305  
 with vesicle formation, 307  
 xerotic, 291, 802
- Keratocele**, 301
- Keratoconus**, 319
- Keratoglobus**, 321
- Kerato-iritis**, 332
- Keratomalacia**, 267, 291, 802
- Keratometry**, 131, 736
- Keratomycosis aspergillina**, 288
- Keratoscope**, 59
- Kerectasia**, 301
- Klebs-Loeffler bacillus**, 230, 245
- Knapp's operation** for pterygium, 675  
 for trachoma, 678
- Koch-Weeks' bacillus**, 226  
 conjunctivitis. *See Conjunctivitis, acute contagious.*
- Kroenlein's operation**, 698
- Kyanopsia**, 550
- LACRIMAL** abscess, 624  
 apparatus, diseases of, 620  
 operations on, 732  
 blennorrhoea of infants, 626  
 bone, caries of, 627  
 periostitis of, 627  
 disease, prognosis in, 627  
 duct, stricture, incision of, 733  
 treatment of diseases of, 628  
 gland, adeno-angioma of, 622  
 adenoma of, 622  
 atrophy of, 621  
 carcinoma of, 622  
 cylindroma of, 622  
 cyst of, 622  
 epithelioma of, 622  
 excision of, 735  
 palpebral portion of, 735  
 extirpation of, 631  
 fibroma of, 622  
 fistula of, 621  
 hypertrophy of, 620
- Lacrimal gland**, lymphoma of, 622  
 mumps of, 620  
 myxoma of, 622  
 osteochondroma of, 622  
 palpebral portion, extirpation of, 631  
 prolapse of, 621  
 sarcoma of, 622  
 syphilis of, 621  
 treatment of diseases of, 628  
 tubercle of, 622  
 tumors of, 622  
 probe, introduction of, 732  
 probes, 629  
 sac, anomalies of, 623  
 capillary fistula of, 625  
 cause of disease of, 626  
 excision of, 631, 734  
 fistula of, 625  
 secretion, character of, in pathologic conditions, 627  
 syringe, introduction of, 733  
 tumor, 624
- Lagophthalmos**, 192, 213
- Lamina cribrosa**, 113
- Landolt's method** of advancement, 730  
 operation for strabismus, 605  
 optotypes, 70
- Lang's operation** for dividing synechia, 689
- Lantern test** for color-blindness, 73
- Largin**, 228, 237
- Latent deviation** of eye muscles, 76  
 strabismus, 77
- Lateral sclerosis**, 528
- Lead**, 587
- Leeches**, 240  
 in iritis, 348
- Lefort-Wolfe transplantation operation**, 674
- Leiter's tubes**, 240
- Lens**, 24  
 concave, 25  
 conjugate focus of a concave, 28  
 of a convex, 26  
 convex, 25  
 focus of a, 25  
 crystalline, 42, 144, 147  
 coloboma of, 430  
 congenital anomalies of, 430  
 dislocation of, 450  
 dislocation of, 427, 450  
 into vitreous, 450  
 under Tenon's capsule, 450  
 examination of, by transmitted light, 111  
 fetal fibrovascular sheath of, 508  
 foreign bodies in, 450  
 increase of size of, 432  
 operations for dislocation of, 450

- Lens, crystalline, removal of, in myopia, 163  
     subconjunctival dislocation of, 450  
     focal distance of a, 31  
     focus of a concave, 27  
     formation of images by a, 28  
     optical center of, 28  
     position of image formed by a convex, 29  
     principal focus of a concave, 27  
         of a convex, 25  
     prismatic deviation of a decentered, 21  
     spectacle, optical center of, 189  
     star, 167  
     virtual focus of a convex, 27  
         image of a concave, 31
- Lenses, 24  
     as prisms, 25  
     bifocal, 187, 188, 191  
     combination of, 36  
         convex and concave, 36  
         cylindric with spheric, 37  
     cylindric, 34  
     glass used in spectacle, 32  
     numeration of, 31  
     spheric, 34
- Lenticonus, 430  
     posterior, 430
- Lepra bacillus, 288  
     of conjunctiva, 273  
     of eyelids, 210  
     of iris, 360
- Leptothrix in canaliculus, 623
- Leroy-Dubois ophthalmometer, 131
- Leukocythemia, 362, 482, 620
- Leukoma, 298  
     adherent, 233, 299
- Leukorrhea, 238
- Levator palpebræ, contraction of, in association with external pterygoid, 213
- Ligamentum pectinatum, 360
- Light, perception of, 95  
     rays of, 22  
     reflex of retinal blood-vessels, 115  
     spot, 113
- Light-difference, 70
- Light-minimum, 70
- Light-perception, qualitative, 70
- Light-reflexes of pupil, 64
- Light-sense, 70  
     in glaucoma, 426  
     of periphery of retina, 95
- Limit of perception, 40
- Line of fixation, 47
- Linear extraction of cataract, 702
- Lipoma of conjunctiva, 271  
     of eyelids, 205
- Lipoma of orbit, 640
- Lippitudo, 200  
     ulcerosa, 199
- Lithemia, 318
- Lithiasis conjunctivæ, 265
- Liver, disease of, 496
- Locomotor ataxia, 67, 528, 587, 592
- Loeffler bacillus. See *Klebs-Loeffler bacillus*.
- Loring's ophthalmoscope, 103
- Lupus, 276  
     of conjunctiva, 273  
     of eyelids, 207  
     of orbit, 642  
     vulgaris of eyelids, 210
- Lymphangiectasis of conjunctiva, 270
- Lymphangioma of caruncle, 278  
     of conjunctiva, 270  
     of orbit, 640
- Lymphoma of conjunctiva, 264  
     of iris, 360  
     of lacrimal gland, 622  
     of orbit, 640
- MACULA, 130, 298  
     disease of cortical center of, 552  
     holes in, 505  
     lutea, 47, 118  
         symmetric changes in, 509  
     traumatic perforations of, 504
- Madarosis, 200
- Maddox rod, 84
- Maddox's obtuse-angled prism, 82
- Magnet of Haab, 335
- Malaria, 291, 304, 308, 437, 456, 496, 519, 528, 608
- Malignant pustule of eyelid, 195
- Malingering, 547
- Manifest deviation of eye muscles, 76
- Mariotte's blind spot, 96
- Massage of cornea, 301  
     of eyeball, 325, 446  
     in embolism, 502  
     in glaucoma, 422  
     vibration, 301
- McKensie Davidson's method with X-Rays, 335
- Measles, 200, 225, 244, 247, 280, 289, 392, 519, 627
- Media, location of opacities in transparent, 112
- Medullated fibers of optic nerve, 510
- Megalocornea, 321
- Megalophthalmos, 325, 632
- Megalopsia, 550
- Meibomian cysts. See *Chalazion*.  
     gland, 206, 265
- Melancholia, 171, 613
- Melanoma of iris, 359

- Melanosis of cornea, congenital, 326  
     scleræ, 336  
 Meningitis, 392, 393, 437, 519, 553,  
     587, 588, 607, 637  
     cerebrospinal, 392, 519  
     simple, 519  
     traumatic, 519  
     tubercular, 519  
 Meningococcus, 454  
 Menstrual disorders, 319, 328, 329, 368,  
     456, 476, 496, 519, 528, 532  
 Mercurial ointment, 313  
 Mercury in iritis, 348  
 Metallic foreign bodies in eye, 334  
 Metamorphopsia, 470  
     binocular, 607  
 Meter angle, 21, 51, 87  
     relation of, to centrad, 52  
 Method of erect or upright image. See  
     *Direct method.*  
     of the inverted image, 127  
 Meynert's fibers, 66  
 Microphthalmos, 325, 439, 540, 618,  
     632  
 Micropsia, 470, 550  
 Migraine, 220, 464, 612  
     ophthalmic, 420  
     ophthalmoplegia, 588  
 Milium, 218  
 Mirror, catoptric power of, 100  
 Mirrors, 99  
     concave, 99  
     convex, 99  
     plane, 99  
 Molluscum contagiosum, 219  
     fibrosum of eyelids, 205  
     sebaceum, 219  
 Mooren's ulcer, 289  
 Morgagni, spheres of, 436  
 Morgagnian cataract, 436  
 Mucocoele, 624  
     of ethmoid, 647  
     of frontal sinus, 646  
 Mules's operation, 695  
 Mumps, 620  
 Muscæ volitantes, 458  
 Mydriasis, 341, 438  
     irritation, 66  
     paralytic, 66  
     springing, 67  
     traumatic, 361  
 Mydriatic nerves, 65  
     tract, 65  
 Mydriatics, use of, 140  
 Myelitis, 519, 528, 532  
 Myodesopsia, 458  
 Myopia, 98, 110, 124, 130, 145, 154,  
     388, 390, 442, 458, 597,  
     606  
 Myopia, amount of lengthening of eye  
     caused by, 124  
     angle gamma in, 159  
     axial, 155  
     cause of, 154  
     ciliary body in, 160  
     correction of, 160  
     curvature, 155  
     determination of, 160  
     diameter of orbit in, 156  
     malignant, 157, 159, 450, 492  
     ordering of glasses for, 164  
     pernicious, 157, 159  
     prodromal, 431  
     progressive, 157  
     prophylactic treatment of, 162  
     reading-glasses in, 183  
     removal of crystalline lens in, 163  
     skiascopy in, 135  
     symptoms of, 157  
     tenotomy of external rectus in, 163  
     transient, in iritis, 343  
     treatment of, 162  
     varieties of, 154  
     with glaucoma, 428  
 Myopic crescent, 158  
 Myosis, 66, 341, 401, 438  
     irritation, 67  
     paralytic, 67  
     spinal, 67  
 Myotic nerves, 65  
     tract, 65  
 Myxedema, 519  
 Myxoma of lacrimal gland, 622  
     of optic nerve, 536  
 NÆVUS pigmentosus of conjunctiva, 271  
 Nasal catarrh, 201, 225  
     duct, anomalies of, 623  
     obstruction of, 625  
 Nasopharynx, diseases of, 626  
 Near point, 48, 45, 75, 181  
     of convergence, 80  
 Nebula, 298  
 Necrosis of orbit, 634  
 Needle operation for cataract, 699  
 Nephritis, 269, 445, 458, 479, 496, 497  
     retinitis in, 477  
     scarlatinal, 479  
 Nerve, optic. See *Optic nerve.*  
 Nerves, mydriatic, 65  
     myotic, 65  
 Neuralgia, 415, 468  
 Neurasthenia, 171, 613  
 Neurectomy, 375  
 Neuritis, descending, 516  
     optic. See *Optic neuritis.*  
     retrobulbar, 519. See *Retrobulbar  
         neuritis.*



- Neuroepithelioma of retina, 506  
 Neuroma of eyelids, 205  
 Neuroretinitis, 345, 376, 479, 516  
 Neurosis, reflex, 613  
 Neurotomy, opticociliary, 427  
 Nevus of iris, 340, 360  
     of orbit, 642. See *Angioma*.  
 Night-blindness, 267, 487, 548  
 Night-terrors, 171, 613  
 Nitrate of silver, 224, 228, 235, 259,  
     278, 292  
 Nitroglycerin in optic-nerve atrophy,  
     531  
 Nodal point, 39, 40  
 Nuclear palsy, acute, 591  
     chronic, 591  
 Nyctalopia, 548  
     acute essential, 549  
     chronic, 549  
     retinitis, 549  
 Nystagmus, 487, 540, 618  
     acquired, 618  
     congenital, 618  
     miners', 618  
     treatment of, 619  
  
 OBLIQUE illumination, 60, 112  
     muscles, insufficiency of, 83  
 Ocular muscles, abnormal balance of.  
     See *Heterophoria*.  
     absence of, 588  
     associated paralyses of, 592  
     congenital defects of, and retraction  
         movements of eyeball, 588  
     insufficiency of. See *Heterophoria*.  
     internal, paralysis of, 593  
     operation for shortening tendons of,  
         731  
     paralysis of external, 578. See  
         also *Strabismus, paralytic*.  
     relative frequency of paralysis of,  
         589  
     tests for balance of, 78-87  
 Oculomotor nerve, 562, 563  
     paralysis of, 213  
     paralyses of, 197, 582  
     recurrent, 588  
 Oculo-orbital fascia, inflammation of,  
     638  
 Operations, 652  
     preparations for, 652  
 Ophthalmia. See *Conjunctivitis*.  
     electric, 550  
     neonatorum. See *Conjunctivitis ne-*  
         *onatorum*.  
     nodosa, 266  
 Ophthalmic artery, aneurysm of, 644  
     migraine, 420  
     vein, obstruction of, 644  
  
 Ophthalmitis, 197, 454  
     destructive, 391  
     migratory, 373  
     sympathetic. See *Sympathetic in-*  
         *flammation*.  
 Ophthalmodynamometer, 87  
 Ophthalmomalacia, 401  
 Ophthalmometer, 131  
     of Javal and Schiötz, 131  
     use of, 736  
 Ophthalmometry, 131, 736  
 Ophthalmoplegia, 591, 639  
     acute, 591  
     chronic, 591  
     external, 591  
     migraine, 588  
     total, 591  
     transient bilateral, 591  
 Ophthalmoscope, 99, 102  
     determination of refraction by the,  
         121  
     direct method of using, 103  
     formation of image in direct method  
         of using, 105  
         in indirect method of using, 108  
     indirect method of using the, 106  
     refraction, 102  
     size of image in direct method of  
         using, 106  
         in indirect method of using, 108  
 Ophthalmoscopy, 99, 109  
     direct method of, 109  
     indirect method of, 127  
 Optic axis, 47  
     canal, fracture of, 542  
     centers, 555  
     chiasm, 66, 554  
     nerve, 66, 111, 113  
         anemia of, 512  
         anomalies of head of, 511  
         atrophy of, 197, 438, 528, 546, 634  
         causes of, 528  
         course of, 530  
         diagnosis of, 530  
         from deformity of skull, 529  
         pathology of, 529  
         prognosis of, 530  
         symptoms of, 523  
         treatment of, 531  
         varieties of, 527  
         visual field in, 525, 526  
         with excavation, 415  
     choroiditic atrophy of, 385, 528  
     coloboma of sheath of, 510  
     congenital anomalies of, 510  
     congestion of, 511  
     consecutive atrophy of, 527  
     degeneration of papillomacular  
         bundle of, 535

- Optic nerve, diseases of, 510  
 engorgement edema of, 522  
 gray atrophy of, 527  
   degeneration of, 528  
 hemorrhage into sheath of, 501  
 hereditary atrophy of, 529, 553  
 homeochronous hereditary atrophy of, 529  
 hyaline bodies in head of, 537  
 hyperemia of, 511  
 injury of, 536  
 medullated fibers of, 510  
 opaque fibers of, 510  
 papulomacular bundle of, 535  
 physiologic variation of, 116  
 pigmentation of fibers of, 511  
 postpapillitic atrophy of, 527  
 primary atrophy of, 527  
 progressive atrophy of, 527  
   with scotoma, 553  
 resection of, 375  
 retinitic atrophy of, 528  
 secondary atrophy of, 527, 529  
 sheath, dilatation of, 523  
 shreds of tissue on head of, 511  
 spinal atrophy of, 527  
 stationary atrophy of, with scotoma, 553  
 tumors of, 536  
 neuritis, 310, 438, 477, **518**, 516, 544, 545, 552, 633, 636, 648  
   causes of, 518  
   congenital, 519  
   course and complications of, 516  
   diagnosis of, 516  
   forms of, 516  
   from brain disease, 519  
   from brain tumor, 518  
     simulating retinitis albuminurica, 521  
   from cord disease, 519  
   from deformities of skull, 519  
   from general diseases, 519  
   from general infection, 519  
   from meningitis, 518  
   from nasal disease, 520  
   from toxic agents, 519  
   infectious, 519  
   inflammatory, 522  
   interstitial, 552  
   intra-ocular, 531  
   mechanism of, 521  
   orbital, 531, 545, 554  
   prognosis of, 517  
   second attacks of, 518  
   significance of, 519  
   spurious, 512  
   sympathetic, 371
- Optic neuritis, symptoms of, 513  
 treatment of, 520  
   with dropping of fluid from nose, 520  
   with scotoma, 553  
   radiations, 555  
   tract, 66, 554  
 Optical center of lens, 189  
 principles, general, 17  
 Opticociliary neurectomy, 697  
 neurotomy, 427, 697  
 vessels, 117  
 Optometer, 131  
 Optometry, 131  
 Optotypes, 70  
 Orbicularis, cramp of, 212  
   pupillary reaction, 67, 68  
 Orbit, aneurysm by anastomosis in, 644  
   angioma of, 640  
   blood cyst of, 641  
   carcinoma of, 641  
   caries of, 634  
   cellulitis of, 269, 586, 636  
     causes of, 636  
     symptoms of, 636  
     treatment of, 638  
   congenital anomalies of, 632  
   cyst of, 632, 641  
   dermoid cyst of, 641  
   diameter of, in myopia, 156  
   diseases of, 520, 632  
   echinococcus cyst of, 641  
   enchondroma of, 640  
   endothelioma of, 641  
   epithelioma of, 642  
   exenteration of, 536, 697  
   exostoses of, 642  
   extirpation of whole contents of, 697  
   extravasation cyst of, 641  
   fibroma of, 640  
   fistula of, 648  
   fracture of, 586, 588  
   hematoma of, 641  
   hemorrhage into, 650  
   injuries of, 650  
   lipoma of, 640  
   lupus of, 642  
   lymphangioma of, 640  
   lymphoma of, 640  
   mucous cyst of, 641  
   necrosis of, 634  
   nevus of, 642  
   osteoma of, 642  
   periostitis of, 217, 586, 588, 633  
   polypi of, 642  
   removal of tumors of, 698  
     by Kroenlein's operation, 698  
   sarcoma of, 641, 642  
   traumatic, 641

- Orbit, tumors of, 213, 539, 586, **640**  
     from periosteum of, 642  
     of bony walls of, 642  
     symptoms of, 639  
     treatment of, 640  
     vascular disease of, 643  
 Orbital disease, general symptoms of, 632  
     veins, phlebitis of, 637  
     thrombosis of, 392  
 Orbito-palpebral cyst, 632  
 Orthophoria, 77, 608  
 Orthoptic exercises in heterophoria, 617  
     training in strabismus, 602  
 Osteoma of conjunctiva, 271  
     of ethmoid, 642  
     of frontal sinus, 642, 646  
     of orbit, 642  
     of sclera, 332  
     of sphenoid sinus, 649  
 Ozena bacillus, 288
- PACHYMEINGITIS, 519  
 Pagenstecher's salve. See *Yellow oxid of mercury*.  
     thread operation for ptosis, 663  
 Panas's fluid, 229  
     method of tenotomy, 725  
     operation for ptosis, 660  
     for strabismus, 605  
 Pannus, 62, **258**, 307  
     phlyctenular, 281, 307  
     treatment of, 262  
 Panophthalmitis, 233, 277, 300, 323, 369, **891**, 392, 695  
     embolic, 476  
     enucleation during, 392  
     evisceration during, 392  
 Papilla. See *Optic nerve*.  
 Papillitis. See *Optic neuritis*.  
 Papilloma of ciliary border, 205  
     of conjunctiva, 271  
     of cornea, 324  
     of eyelid, 204  
     of iris, 340  
 Papillomacular bundle, 555  
     degeneration of, 505  
 Papilloretinitis, sympathetic, 371  
 Paracentesis corneæ, 241, 293, 295, **680**  
 Parallax test, 404  
     for heterophoria, 78  
 Paralysis agitans, 528  
 Paretic dementia, 67, 519, 528, 587, 592  
 Parinaud's conjunctivitis, 264  
 Pemphigus, 214, 267  
     of conjunctiva, 276  
 Perception, limit of, 40  
 Perimeter, 90  
     self-registering, 91  
 Periostitis of orbit, 217, 633  
 Perithelioma of choroid, 395  
 Peritomy, 262  
 Perivasculitis, 474, **496**, 497  
 Permanganate of potassium, 236, 240  
 Peronin, 657  
 Peroxid of hydrogen, 229, 236  
     in powder-burns, 222  
 Persistent hyaloid artery, 462  
     pupillary membrane, 338, 540  
 Pfeiffer's capsulated bacillus, 288  
 Phakolysis, 163  
 Phlyctenular keratitis, 279  
     kerato-conjunctivitis, 279  
     pannus, 281  
 Phorometer, 81  
 Photometer, 70  
 Photometric types, 70  
 Phthiriasis, 203  
 Phthisis bulbi, 365, 392, 401  
     essential, 401  
 Physiologic cup, 113, 116  
     salt solution, injections of, into vitreous, 715  
     subconjunctival injections of, 680  
 Pilocarpin diaphoresis, 328, 331, 368, 386  
     in iritis, 352  
     in glaucoma, 421, 422  
     in scleritis, 328, 331  
 Pinguecula, 269  
 Pink eye, 226  
 Placido's disc, 59  
 Pneumococcus, 225, 230, 627  
     conjunctivitis, 227  
     in corneal ulcers, 287  
     of Fränkel, 227  
 Pneumonia, 304  
 Point of reversal, 132, 135  
 Polioencephalitis, 591  
 Polycoria, 338  
 Polyneuritis, 519  
 Polyopia, 432  
 Porus opticus, 115  
 Pregnancy, 479  
 Prentice's method of numbering prisms, 20  
 Presbyopia, 46, **180**, 223  
     causes of, 180  
     correction of 180  
     premature, from diabetes, 543  
 Priestley Smith's theory of strabismus, 598  
 Primary deviation, 574  
     position of eyes, 563  
 Prince's method of advancement, 731  
 Prism, 19  
     angle of deviation of, 19  
     deviation produced by a, 20

- Prism, exercises with, 153, 606, 614  
 obtuse-angled, 82  
 refracting angle of, 19  
 refraction through a, 19  
 rotary, 81  
 test for heterophoria, 78
- Prism-convergence, 80
- Prism-diopter, the, 20
- Prism-divergence, 80
- Prismosphere, 616
- Prisms, 19  
 exercises with, 153, 614  
 numbering of, 20  
 overcoming, 569  
 prescription of, in heterophoria, 615
- Proptosis, 98, 632
- Protargol, 228, 235, 236, 237, 240, 260, 278, 292, 293, 297
- Protractor, 189
- Pseudochorea, 171
- Pseudoglioma, 391, 454, 508
- Pseudo-isochromatic plates of Stilling, 75
- Pseudo-ptyerygium, 268
- Psoriasis, 264, 276
- Psorophthalmia, 199
- Pterygium, 268  
 actual cautery in treatment of, 676  
 congenital, 223  
 excision of, 675  
 keloid formation after removal of, 676  
 operations for, 675  
 subinvolution of, 675  
 transplantation of, 675
- Ptomain-poisoning, 587, 591
- Ptoxis, 218, 547  
 congenital, 193  
 unilateral, 213  
 lipomatosis, 205  
 operations for, 660  
 partial, 401
- Puerperal sepsis, 392
- Pulsating exophthalmos, 643
- Pulsation of retinal vessels, 116
- Pulvinar, 555
- Puncta lachrymalia, acquired anomalies of, 622  
 congenital anomalies of, 622
- Punctum proximum. See *Near point*.
- remotum. See *Far point*.
- Pupil, 62  
 accommodation reflex of, 64  
 Argyll-Robertson, 67  
 cerebral cortex reflex of, 67  
 consensual light reflex of, 64  
 contraction of, 66  
 convergence reflex of, 64  
 dilatation of, 66  
 reflexes of, 65  
 direct light reflex of, 64
- Pupil, exclusion of, 345  
 Gifford-Galassi reflex of, 68  
 Haab's reflex of, 68  
 in hemianopsia, 561  
 indirect light reflex of, 64  
 measurement of, 63  
 occlusion of, 345  
 orbicularis-reaction of, 67, 68  
 pain-reaction of, 65  
 reaction of, to drugs, 65  
 relaxation reflexes of, 65  
 sensory reflex of, 65  
 skin-reflex of, 65  
 varying inequality of, 67  
 Westphal-Piltz reflex of, 68
- Pupillary membrane, 441  
 persistent, 338, 540
- Pupillometer, 64
- Pupil-reactions, 63
- Pupil-reflexes, 63
- Pupils, special reaction of, 67  
 unequal, 67
- Purpura, 496
- Pyemia, 392, 496
- Pyoktanin, 209, 296
- QUININ amaurosis, 545
- RABBIT'S conjunctiva, transplantation of, 276, 677  
 cornea, transplantation of, 302
- Rachitis, 308, 437
- Rays, 22  
 convergent, 24  
 divergent, 24  
 of light, 22  
 parallel, 24  
 significance of the different, 24
- Rectus, external. See *External rectus*.
- Red-blindness, 72, 541
- Red-green blindness, 541
- Reflection, 99
- Refraction, 17  
 abnormal, 144  
 angle of, 18  
 determination of, by the ophthalmoscope, 121  
 estimation of, by indirect method, 130  
 index of, 18  
 normal, 144  
 through a prism, 19
- Reid ophthalmometer, 131
- Relapsing fever, 519
- Relative accommodation, 53, 76
- Retina, 118  
 acuity of vision of peripheral parts of, 95  
 adaptation of, 95, 548  
 anemia of, 464

- Retina, anesthesia of, 466, 551  
   angioid streaks in, 498  
   apoplexy of, 494  
   atrophy of, 470  
   blood-vessels of, 114  
   changes in, from electric light, 515  
     from sunlight, 505  
   congestion of, 148  
     capillary, 463, 465  
   corresponding points of, 568  
   cysticercus of, 492, 509  
   degeneration of ganglion-cells of, 509,  
     530, 535, 544, 546  
   detachment of, 112, 163, 396, 427,  
     438, 459, 486, 490, 505  
     causes of, 492  
     diagnosis of, 492  
     mechanism of, 492  
     symptoms of, 490  
     treatment of, 493  
   diseases of, 463  
   edema of, 499  
   embolism of central artery of, 498,  
     552  
     causes of, 501  
     diagnosis of, 501  
     symptoms of, 498  
     treatment of, 502  
   glioma of, 396, 506  
     prognosis of, 509  
   gyrate atrophy of, 485  
   hemorrhages in, 494  
   hyperemia of, 463  
   hyperesthesia of, 465  
   irritation of, 465  
   ischemia of, 464  
   light reflex of vessels of, 115  
   light-sense of periphery of, 95  
   neuro-epithelioma of, 506  
   pigment striæ in, 498  
   pigmentary degeneration of. See  
     *Retinitis pigmentosa*.  
   pulsation of blood-vessels of, 116  
   rupture of, 505  
   sclerosis of, without pigmentation,  
     488  
   spontaneous pulsation of veins of,  
     116  
   structure of, 554  
   subhyaloid hemorrhage of, 494  
   symmetric changes in macula of, 509  
   traumatic amblyopia of, 504  
     anesthesia of, 504, 551  
     edema of, 504  
     perforations of macula of, 504  
   traumatism of, 503  
   variations in the distribution of vessels  
     of, 117  
 Retinæ commotio, 504
- Retinal artery, central, embolism of,  
   498  
   endarteritis of, 501  
   spasm of wall of, 501  
   thrombosis of, 502  
 image in ametropia, 40  
   in emmetropia, 40  
 vein, central thrombosis of, 502  
 vessels, aneurysm of, 498  
   disease of, 427, 496  
   endarteritis of, 473  
   intermittent blood stream in, 499  
 Retinitis, 456, 468, 492, 508  
   albuminuric, 428, 477  
     causes of, 479  
     course and complication of, 480  
     degenerative type of, 479  
     diagnosis of, 481  
     exudative type of, 479  
     forms of, 479  
     of pregnancy, 479  
     pathology of, 480  
     prognosis of, 480  
     symptoms of, 477  
     treatment of, 481  
     unilateral, 479  
   central punctate, 485  
     and striate, 485  
     relapsing, 473, 475  
   circinata, 484, 508  
   course and complications of, 471  
   diabetic, 482  
     central punctate, 482  
   diagnosis of, 470  
   diffuse, 472  
   edema of, 472  
   electric, 505  
   hemorrhagic, 318, 476  
   leukocythemiac, 482  
   macularis, syphilitic, 475  
   nyctalopia, 549  
   of Bright's disease. See *Retinitis*,  
     *albuminuric*.  
   parenchymatous, 468, 472  
   pathology of, 468  
   pigment in, 470  
   pigmentosa, 383, 442, 486, 489, 552  
     causes of, 489  
     pathology of, 489  
     symptoms of, 489  
     varieties of, 488  
     visual field in, 487  
   primary purulent, 476  
   prognosis of, 471  
   proliferating, 482  
   punctata albescent, 485  
   purulent, 475  
   renal. See *Retinitis, albuminuric*.  
   septic, 475

- Retinitis, serous, 468, **472**  
     simplex, 472  
     solar, 505  
     striata, 485  
     symptoms of, 469  
     syphilitic, **478**, 550  
     treatment of, 471  
     varieties of, 468  
 Retinochoroiditis, 381, 552  
     atrophic, 470  
     syphilitic, 473  
 Retinoscopy. See *Skiascopy*.  
 Retrobulbar neuritis, **581**, 552  
     acute, 531  
     causes of, 532  
     treatment of, 533  
     chronic, 533  
     causes of, 534  
     treatment of, 536  
 Rheumatism, 308, 328, 329, 350, 368,  
     519, 532, 587, 608, 638  
     gonorrheal, 243  
 Rhinitis, 247, 282  
     atrophic, 368  
     infectious, 280  
 Rhinopharynx, diseases of, 466, 646  
 Risley's rotary prism, 81  
 Rod test of heterophoria, 84  
 Rodent ulcer of eyelids, 207, 208  
 Roentgen rays. See *X-rays*.  
  
 SAEMISCH's section, 295, 681  
     ulcer of cornea, 286  
 Salicylate of sodium in glaucoma, 421  
 Salicylic acid in iritis, 351  
 Sarcoma of antrum, 650  
     of brain, 518  
     of caruncle, 278  
     of choroid, **898**, 427, 492, 508  
     of ciliary body, 366, 397  
     of conjunctiva, 271, 273  
     of cornea, 324  
     of eyelids, 207  
     of iris, 359  
     of lacrimal gland, 622  
     of optic nerve, 536  
     of orbit, 641, 642  
     of sclera, 332  
     traumatic, of orbit, 641  
 Savage's operation for shortening ten-  
     don, 731  
     orthoptic exercises in heterophoria,  
         614  
 Scarlet fever, 225, 244, 289, 519, 532,  
     627, 637  
 Schlemm's canal, 416, 417  
 Schmidt-Rimpler's method of estimat-  
     ing refraction, 130  
 Schweigger's hand perimeter, 91  
 Schweigger's method of advancement,  
     731  
 Sclera, abscess of, 332  
     congenital pigmentation of, 336  
     diseases of the, 327  
     enchondroma of, 332  
     fibroma of, 332  
     injuries of, 332  
     prognosis of, 333  
     treatment of, 333  
     melanosis of, 336  
     operations upon, 689  
     osteoma of, 332  
     perforating wounds of, 333  
     perforation of, during tenotomy, 726  
     pigment spots in, 336  
     rupture of, 332  
     sarcoma of, 332  
     staphyloma of, 331  
     tumors of, 332  
     ulcer of, 332  
     vasomotor dilatation of vessels of, 329  
     wounds of, 332, 333  
 Scleral ring, 113  
     sutures, 334  
     wounds, infected, cauterization in,  
         336  
 Scleritis, 59, 329  
     gummatous, 329  
     scrofulous, 330  
     treatment of, 331  
 Sclerochorioretinitis, intra-uterine, 325  
 Sclerokeratitis, 329  
 Sclerokerato-iritis, 330  
 Sclerophthalmia, 325  
 Scleroticocoroiditis, 156, 381  
     posterior, 389  
 Sclerotome, 690  
 Sclerotomy, 369, 426, 502, **689**  
     anterior, 689  
     in detachment of retina, 493, 494  
     in hydrophthalmos, 321  
     internal, 690  
     posterior, 428, 690  
 Scopolamin, 142  
     in iritis, 348  
 Scotoma, **96**, 380, 386, 387, 504, 505,  
     525, 543, 546, 549, **552**,  
     597  
     absolute, 96  
     central, 96  
     detection of, 96  
     in glaucoma, 409  
     in hysteria, 552  
     negative, 96  
     paracentral, 96  
     positive, 96  
     relative, 96  
     ring, 96, 552

- Screen-test for heterophoria, 78  
 Scrofula, 244, 252, 308, 328, 329  
 Scrofulous ophthalmia, 247  
 Scurvy, 496, 548  
 Seborrhea, 218  
     of eyelids, 199  
 Seborrhœa nigricans, 219  
 Second sight, 156, 431  
 Secondary deviation, 574  
     positions of eyes, 564  
 Septicemia, 392, 496  
 Serpiginous ulcer of cornea, 286  
 Sexual abuses, 466, 528  
 Shadow-test. See *Skiascopy*.  
 Sick-headaches, 464  
 Sideroscope, 335  
 Siderosis bulbi, 336  
     conjunctivæ, 278  
 Sinuses, affections of, 586, 646  
 Sixth nerve. See *Abducens*.  
 Skiascopy, 99, 182  
     in emmetropia, 137  
     in hyperopia, 136  
     in irregular astigmatism, 139  
     in myopia, 135  
     in regular astigmatism, 137  
     with concave mirror, 139  
     with plane mirror, 134  
 Skin-grafting, Thiersch's method of, 674  
     without a pedicle, 674  
 Small-pox, 196, 225, 289, 392, 519, 620, 627  
 Snellen's artificial eye, 694  
     method of tenotomy, 725  
     suture operation for ectropion, 670  
     test-types, 41, 75  
 Snow-blindness, 549  
 Spectacles, adjustment of, 188  
 Spectroscope, 75  
 Sphenoid, diseases of, 532, 648  
     sinus, diseases of, 648  
         hyperostoses of, 649  
         osteoma of, 649  
         polypi of, 649  
 Spheric lenses, 34  
 Sphincter pupillæ, 65  
 Spinal myosis, 67  
 Sponge-grafting into orbit, 697  
 Squint. See *Strabismus*.  
 Staphylococci, 201, 225, 230, 245, 247, 288, 289, 355  
     in corneal ulcers, 287  
 Staphyloma, 98, 213  
     anterior, 233  
     congenital, of cornea, 326  
     of cornea, 284, 299, 300  
     of sclera, 331  
     operations for, 682  
     posterior, 159, 389, 511  
 Stellwag's sign in goiter, 645  
 Stenopaic slit, 174  
     spectacles, 179  
 Stereoscope, 602, 603  
 Stevens's classification of heterophorias, 77  
     method of tenotomy, 727  
     phorometer, 81  
 Stilling's plates for color-blindness, 75  
 Strabismus, 76, 98, 179, 540, 570  
     alternating, 594, 605  
     amblyopia of eyes in, 596  
     angular method of measurement of, 600  
     concomitant, 594  
         causes of, 594  
         single vision in, 598  
         treatment of, 601  
         varieties of, 594  
     congenital paralytic, 588  
     constant, 594  
     convergent, 147, 570, 571, 573, 594  
         concomitant, advancement in, 604  
             bar reading in, 603  
             educative treatment of, 601  
             occlusion of fixing eye in, 602  
             operative treatment in, 604  
             orthoptic training in, 602  
             spectacle treatment of, 601  
             tenotomy in, 604  
             treatment of, 601  
             results of tenotomy in, 606  
     deorsumvergent, 571, 578  
     difference between, and heterophoria, 611  
     divergent, 157, 571, 594  
         concomitant, advancement in, 606  
             glasses in, 606  
             operations for, 606  
             tenotomy in, 606  
             treatment of, 605  
     dynamic, 77  
     latent, 77  
     measurement of, 599  
         by method of tangents, 600  
     monocular, 594, 605  
     operations for, 723  
     paralytic, 573  
         causes of, 586  
         diagnosis of affected eye in, 582  
         from injury, 588  
         general symptoms of, 574  
         method of examination of eye in, 582  
         of basal origin, 587  
         of central origin, 587  
         of cerebral origin, 587  
         of congenital origin, 588  
         orbital, 586  
         position of head in, 575

- Strabismus, paralytic, primary deviation**  
     in, 574  
     prognosis of, 589  
     relative frequency of muscle affected in, 589  
     secondary deviation in, 574  
     special symptoms of, 576  
     table of diagnostic symptoms of, 583  
     diplopia in, 585  
     treatment of, 590  
     periodic, 594  
     spastic, 607  
     suppressed, 77  
     sursumvergent, 571, 578  
     vertical, 573, 594  
**Strabisometer, 600**  
**Streptococci, 225, 230, 244, 245, 265, 288**  
     in corneal ulcers, 287  
**Streptococcus, 627**  
     diphtheria of conjunctiva, 245  
**Stroscheim flasks, 656**  
**Strychnin in heterophoria, 613**  
     in optic-nerve atrophy, 531  
**Stye, 195**  
**Subconjunctival injections, 313, 314, 328, 368, 375, 386, 680**  
     in corneal opacities, 301  
     ulcers, 296  
     in detachment of retina, 494  
     in iritis, 349  
**Subhyaloid hemorrhage, 494**  
**Suction method for cataract, 701**  
**Sulphate of copper, 251, 259, 282**  
**Sulphuric acid poisoning, 591**  
**Sunstroke, 519**  
**Superior oblique, 563**  
     paralysis of, 581  
     rectus, 562  
     paralysis of, 578  
     tenotomy of, 725  
**Suprarenal capsule, extract of, 224, 250, 265, 658**  
**Sursumduction, 80, 81**  
**Sursumvergence, 80, 81**  
**Sutures, 655**  
**Sweet's method with X-rays, 335**  
**Symblepharon, 214**  
     congenital, 192  
     operations for, 676  
**Sympathectomy, 321, 426, 428**  
**Sympathetic affections, conditions producing, 369**  
     ganglion, superior cervical, excision of, 321, 426, 428  
     inflammation, 318, 323, 369, 370, 696  
     pathogenesis of, 372  
     period of incubation of, 372  
**Sympathetic inflammation, prognosis of, 376**  
     prophylaxis of, 373  
     rules for enucleating to prevent, 374  
     treatment of, 373  
     irritation, 66, 369, 370, 696  
     symptoms in eye exciting, 370  
     ophthalmia. See *Sympathetic inflammation*.  
     ophthalmitis. See *Sympathetic inflammation*.  
**Sympathizing eye, 369**  
**Synchysis, 459**  
     scintillans, 459  
**Synechia, anterior, 296, 299, 427**  
     division of, 689  
     posterior, 342, 427  
**Syphilis, 308, 347, 352, 365, 368, 385, 415, 437, 445, 456, 473, 474, 477, 519, 529, 532, 586, 591, 594, 627, 634, 646**  
     hereditary, 308, 385  
     in oculomotor palsies, 586  
     of conjunctiva, 270  
     of eyelids, 203  
**TABES. See Locomotor ataxia, 67**  
**Tachycardia, 171, 613**  
**Tansley's operation for ptosis, 662**  
**Tarsadenitis meibomica, 206**  
**Tarsal tumor. See Chalazion.**  
**Tarsitis, 210**  
**Tarsorrhaphy, 664**  
**Tarsus, enchondroma of, 205**  
**Tattooing of cornea, 302, 683**  
**Teale's operation for symblepharon, 676**  
**Tendo oculi, 624**  
**Tenonitis, 586, 638**  
     after tenotomy, 726  
**Tenon's capsule, 391**  
**Tenotomy, 98, 723**  
     complete, 723  
     complications after, 725  
     graduated, 726  
     in heterophoria, 618  
     in convergent concomitant strabismus, 604  
     in divergent strabismus, 606  
     in heterophoria, 617  
     subconjunctival method of, 724  
**Tension, intra-ocular, 97**  
**Tensor choroidea, 42**  
**Test-types, 41, 68, 69**  
**Thiersch's method of skin-grafting, 674**  
**Thiosinamin, 301**  
**Third nerve. See Oculomotor nerve.**  
**Thomson's lantern test for color-blindness, 73, 74**



- Thomson's method of detecting color-blindness, 73  
 Thrombosis of central retinal artery, 502  
     vein, 502  
 Tinea tarsi, 199  
 Tobacco, 587, 591  
 Tobacco-amblyopia, 533, 545, 549  
 Toluidin-blue, 60  
 Tonometer, 98, 402  
 Torsion, 564  
     inward, 562, 563  
     outward, 562, 563  
 Toxalbumin, 587  
 Trachoma, 214. See *Conjunctivitis, granular*.  
     bodies, 253  
     coccus, 253  
 Tractus. See *Optic tract*.  
 Transplantation of skin without a pedicle, 674  
 Trichiasis, 200, 215, 258  
     double transplantation operations for, 666  
     operations for, 665  
 Trichosis carunculae, 278  
 Trochlear nerve, 563  
 Tropacocain, 656  
 Tropometer, 570  
     use of, 740  
 Tscherning's accommodation theory, 42  
 Tubercle bacillus, 275, 288  
     of brain, 518  
     of iris, 358  
     of optic nerve, 536  
 Tuberculin, 276  
 Tuberculosis, 252, 308, 386, 519, 591, 646  
     of choroid, 398  
     of conjunctiva, 274  
     of cornea, 289  
 Tumors, intra-ocular, 369  
     of brain, 518  
 Tylosis, 200  
 Typhoid fever, 289, 304, 519, 594, 637, 638  
 Typhus fever, 289, 519  
 ULCER of conjunctiva, 269  
     of cornea, 232, 240, 243, 277, 288, 438, 442, 444, 636, 657. See also *Cornea, ulcer of*.  
 Ulcer, rodent, 209  
     tertiary, of eyelids, 203  
 Ulcerans mycotica, 290  
 Umbilical vein, inflammation of, 392  
 Underlying conus, 116  
 Urethral hemorrhage, 544  
 Uric-acid diathesis, 608  
 Uterine disease, 467, 608  
 Uvea, congenital ectropion of, 340  
 Uvéite irienne, 350  
 Uveitis, 367  
     sympathetic, 371  
 VACCINE vesicles in eyelids, 196  
 Valk's operation for shortening tendon, 731  
 Van Fleet's operation for ptosis, 662  
 Van Millingen's tarsocheiloplastic operation, 667  
 Vasculitis, 496  
 Vertigo, 171, 575, 613  
 Vibration massage, 301  
 Vicarious fovea, 599  
 Violet-blindness, 72, 541, 542  
 Vision, abnormalities of field of, 96  
     amblyopia of field of, 551  
     binocular, 567  
     field of, 92  
     method of testing, 607  
     single, 76, 568  
 Bjerrum's method of ascertaining field of, 91  
     color-field of, 93  
     false projection of field of, in paralytic strabismus, 575  
     field of, 87  
     in glaucoma, 407  
     in hysteria, 547  
     in optic-nerve atrophy, 525  
     in retinal anesthesia, 467  
     for colors, direct, 75  
     iridescent, in glaucoma, 411  
     method of ascertaining field of, 87-91  
     monochromatic, 72  
     normal acuteness of, 40  
     of peripheral parts of retina, acuity of, 95  
     relative field of, 92  
     testing acuteness of, 68  
 Visual acuteness, 40  
     angle, 39  
     axis, 47  
     conduction paths, 554  
     ganglia, primary, 555  
     line, 47  
     rotation of eyeball around, 564  
     tract, 554  
     zone, 139  
 Vitreous, 144  
     blood-vessel formation in, 460  
     cholesterin in, 459  
     cysticerci in, 461  
     detachment of, 461  
     diseases of, 453  
     dust-like opacities of, 456  
     entozoa in, 461

- Vitreous, examination of, 112  
 fatty degeneration of, 457  
 filaria sanguinis in, 461  
 fluidity of, 459  
 foreign bodies in, 334, 461  
 hemorrhage into, 458, 492  
 opacities, 112, 455  
   causes of, 456  
   treatment of, 457  
 purulent inflammation of, 453  
 spontaneous hemorrhage into, 459  
   inflammation of, 453
- WEEKS' bacillus, 226
- Wernicke's symptom, 561. See *Hemioptic pupillary inaction*.
- Westphal-Piltz reaction, 68
- Wharton-Jones operation for ectropion, 671
- Whooping-cough, 304, 392, 464, 545, 587
- Wilder's operation for ptosis, 663
- Wolfberg's tests, 69
- XANTHELASMA, 205
- Xanthoma, 205
- Xanthopsia, 549
- Xeroderma pigmentosum, 276
- Xerophthalmos, 266
- Xerosis bacilli, 206, 226, 245, 267  
   of conjunctiva, 251, 266, 302, 549
- X-rays in detecting foreign bodies, 335, 452  
   in epithelioma of eyelids, 210
- YELLOW oxid of mercury, 202, 207, 248, 250, 260, 282, 292, 296, 308, 313, 316  
   spot. See *Macula lutea*.
- ZEISS's glands, 195
- Zone of Zinn, 42







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